

ELECTRICAL ENGINEERING

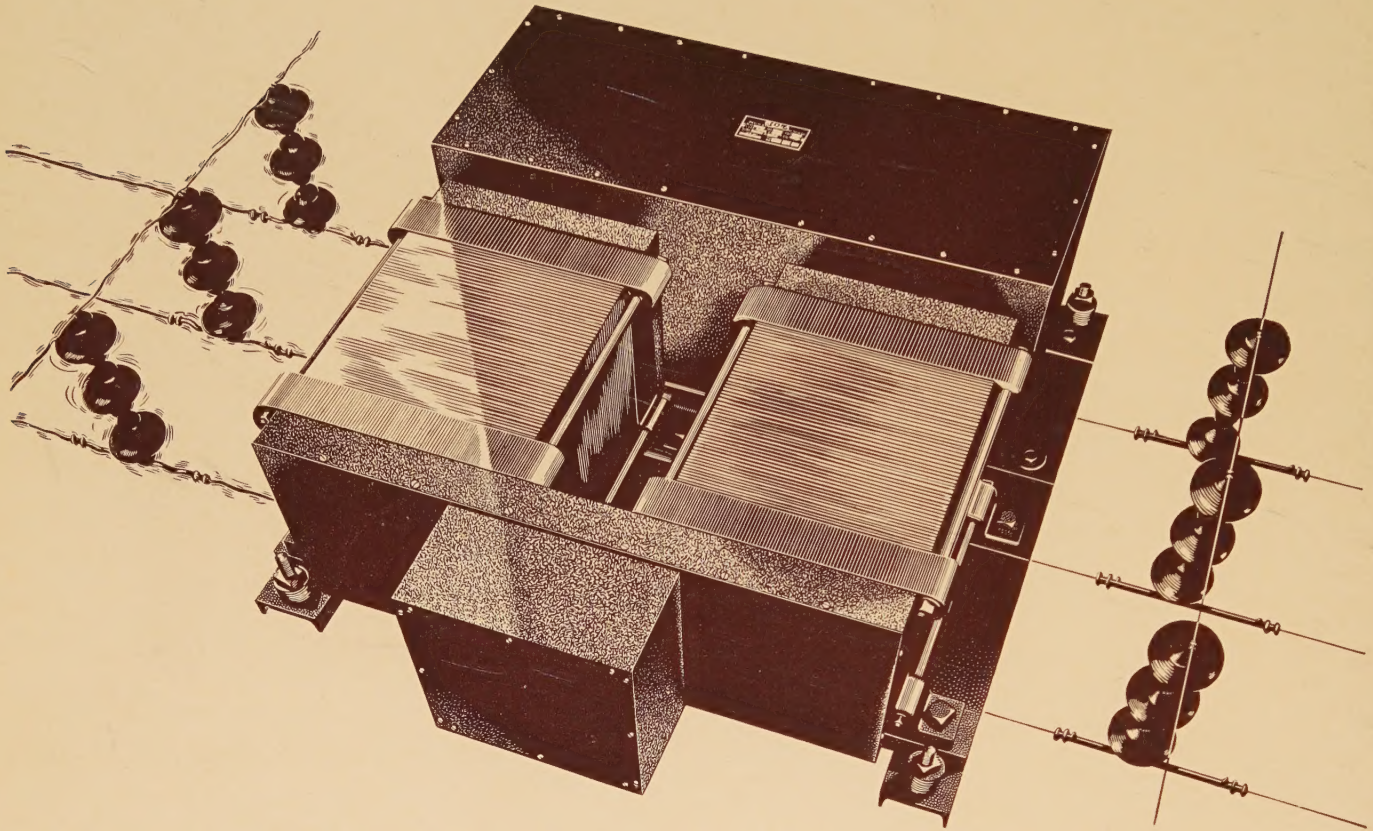


APRIL

1943

AIEE DISTRICT TECHNICAL MEETING, KANSAS CITY, MO., APRIL 28-30, 1943

Industry steadies its "nerves"



FACED with production schedules that have no precedent in history, American industry finds the fluctuating voltages of its over-loaded power lines wholly inadequate to meet the "deadly" precision demanded for total war.

Vital "nerve centers" of production lines are geared for precise performance when operated at specific line voltages. Any variation from these rated values, and there are many these days, may well mean lagging production schedules and a noticeable lack of uniformity in products.

Fluctuating line voltages are no problem in plants where Sola "CV's" have taken over. Even though the peaks and valleys of power consumption may cause a voltage variation of as much as $\pm 30\%$ —the vital "nerve centers" of their pro-

duction lines continue to operate smoothly and with unerring precision.

Day and night, without care or supervision, Sola Constant Voltage transformers maintain positive control over electrically operated instruments and machines that are indispensable to the nation's war effort. These transformers are available in standard units with capacities ranging from 15 KVA, which might be used for an entire communications system for instance, to the small 10 VA units for vacuum tubes. Special units can be built to specifications.

Note to Industrial Executives: *The problems solved by Sola "CV" transformers in other plants may have an exact counterpart in yours. Find out. Ask for bulletin ACV-74.*

Constant Voltage Transformers

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-ray Equipment • Luminous Tube Signs • Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells and Chimes • etc. **SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago, Ill.**

ELECTRICAL ENGINEERING

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APRIL

1943



The Cover: The Liberty War Memorial, Kansas City, Mo., where the AIEE South West District technical meeting will be held (*see pages 168-70*), commemorates World War I as the nation engages in the struggle of World War II.

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Group of 1943 Science Talent Search Winners leaving the Pan-American Union Building after discussing South American relations with Dr. L. S. Rowe, Director-General.

Prospecting for future scientists

Every step forward in science brings with it a need for more scientists. Not technicians merely, but men and women who are capable of creative achievement.

Where are they to be found?

It seems highly probable that aptitude for creative achievement in science can be discovered as early as the senior year in high school.

It is quite certain that early discovery of ability helps crystallize the interests of the students and stimulates them to further activity.

For these reasons, Science Service, Science Clubs of America and Westinghouse are cooperating in an annual Science Talent Search. Methods employed in the Science Talent Search, including the science aptitude tests, were devised by Dr. Harold A. Edgerton, Ohio State University, and Dr. Stuart Henderson Britt, Office of Psychological Personnel, National Research Council.

Each year, 40 boys and girls selected on the basis of the criteria set up by Dr. Edgerton and Dr. Britt, are taken to Washington as guests of Westinghouse. There, after further examinations and interviews, those who qualify receive Westinghouse Science Scholarships ranging from \$100 to \$2400.

Last year, 20 Westinghouse Science Scholarships were

awarded, but every boy and girl selected for the trip received offers of scholarship help from leading colleges and universities.

Every one entered college.

Every one is making a scholastic record considerably above the average.

Since the Science Talent Search is only in its second year, there are yet no data on the correlation between aptitude as measured by the methods employed and actual achievement in science. Dr. Edgerton and Dr. Britt have, however, begun a projected ten-year study of these boys and girls, covering their work in college and the early part of their after-college careers.

Full information on the Science Talent Search, including reprint of an article by Dr. Edgerton and Dr. Britt describing the methods employed, will be sent on request. Write to Science Service, 1719 N Street, Washington, D. C., or to School Service, Westinghouse Electric & Manufacturing Co., 306 Fourth Ave., Pittsburgh, Pa.

Westinghouse

PLANTS IN 25 CITIES

OFFICES EVERYWHERE

The Role of Lighting in Accident Prevention

H. L. LOGAN

MEMBER AIEE

ACCORDING to Rear Admiral W. H. P. Blandy, speaking to the National Safety Congress in Chicago, Ill., on October 27, 1942, "Since Pearl Harbor, almost as many people have been accidentally killed in the United States, including 42,600 war workers, as have been killed by German bombing in England in three years!"

"Since Pearl Harbor, more Americans have been permanently disabled by accidents on the home front than the total of military forces wounded, captured, and killed in action.

"Since Pearl Harbor, accidents have cost us more than 3,000,000,000 man-hours."

To this toll must be added an economic loss of at least \$3,750,000,000, according to the National Safety Council. The accident toll is so huge that it is a major handicap to winning the war.

ACCIDENTS ARE PREVENTABLE

Once upon a time accidents were accepted as an inescapable feature of industry. We now know that accidents can be prevented, and as our supply of workers is limited we cannot afford to lose them through accidents. Wars may not be won by armies that follow the slogan, "safety first," but they may be lost by managements and workers that do not.

Much is known now about the technique of accident prevention. A profession has grown up that makes this subject its exclusive field—the profession of "safety engineering." Its members have many years of successful practice behind them, but right now they are faced with a new combination of circumstances. We have become a 24-hour nation—the greater part of our expanded production occurs under artificial lighting; the production rate has tripled or quadrupled; plant areas and facilities are occupied by two, three, and four times the number of workers for which they were planned; many workers are new and inexperienced, others are old, some are females, most work longer hours—so that the trend of the accident curve has been reversed, and it is rising.

LIGHTING AND ACCIDENTS

Now that every preventive measure is "worth its weight in tanks and guns," national attention has been focused on the accident menace, and many means are

being sought to hold it in check. If these various means assured complete success, there would be no need to add to the library that is already available on the subject of accident prevention. The justification for these remarks lies in the fact that *all* of the causes of the accident

rate are not under satisfactory control and specifically, that one of these causes—the close dependence of accidents on sight, and so on light—is not understood sufficiently. There will be little new in the evidence presented here, but this evidence shows relationships in its collected form that were not easy to see as long as it remained scattered.

There is, of course, a general vague belief that lighting is somehow tied up with a certain percentage of accidents, but a pious belief in a connection between light and safety is of little practical help. Much wider and clearer knowledge of the use of good lighting in protecting workers is needed to stimulate its use as a safeguard.

The black-out has brought home to large numbers of people their almost complete dependence on visibility for safety. They have discovered that they can hardly move ten paces in a complete black-out without running the risk of at least a minor accident. The English people cite the black-out as the most dismaying feature of the war. In areas where it is most severe, pedestrian fatalities have risen 400 per cent over prewar figures, despite a drastic reduction in traffic.¹

The personal experience of everyone supports the statement that an accident is probable in the sudden absence of sight or light. Light, therefore, replaces the *probability* of accidents with mere possibilities, and reflection makes clear that these possibilities may be further reduced by the kind of lighting that provides certainty of seeing.

VISIBILITY AND TRAFFIC ACCIDENTS

The clearest specific connection between uncertain seeing caused by poor visibility and accidents has been shown in traffic accident studies. L. J. Schrenk² reports that automobile traffic fatalities at night in the city of Detroit, Mich., became seven times the daytime fatalities from 1934 to 1936, when street lighting was reduced

H. L. Logan is managing engineer in the Controlens division of the Holophane Company, Inc., New York, N. Y.

owing to the depression. These fatalities dropped to 1.4 times the daytime rate in 1937, when the street lighting was restored.

A study of traffic accidents* in 46 cities the first year, 227 cities the second year, and 60 cities the third year of a 3-year investigation showed that fatalities owing to a lighting cause were from 46 to 50 per cent of the total nighttime fatalities. Nonfatal accidents showed the same proportions.³

G. D. Newton,³ Travelers Insurance Company, Hartford, Conn., made an investigation* on a national scale of the number of fatalities occurring during the four evening rush hours, 5 p.m. to 9 p.m., and those occurring during the morning rush hours, 6 a.m. to 10 a.m. The evening fatalities were 281 per cent of the morning fatalities.

A comparison of police records,⁴ 5 a.m. to 7 a.m., winter and summer (dark in winter, light in summer), and always a period of relatively light traffic, shows winter fatalities 218 per cent of summer fatalities.⁵

It appears that decreased visibility on the highways increases the number of fatalities that would occur otherwise from two to seven times. It is significant to note that recent dim-out and black-out experience here and abroad abundantly reinforces these figures.

This "law," that the provision of proper visibility automatically reduces night traffic accidents from 50 to 88 per cent, is of great importance to industrialists when coupled with the fragmentary, but confirming, data from industrial tests.

So close and constant is the relationship between visibility and traffic accidents that when during the depression many municipalities economized on their street lighting, night accidents climbed in all cases. Conversely, when former lighting levels were restored, the accident rates dropped. Traffic experts now have proved that the rate of night accidents can be dropped to the rate of day accidents by the adequate use of artificial lighting.²

VISIBILITY AND INDUSTRIAL ACCIDENTS

Insurance experts⁴ after long experience with industrial accidents, charge 15 per cent to poor illumination. Doctor Frank Allport, of the American Society of Safety Engineers, stated some years ago that improper illumination is the basic cause of 25 per cent of industrial accidents. Doctor J. R. Wittekind, chairman of the industrial relations committee of the American Optometric Association, says that poor vision (defective eyes and poor lighting) are responsible for 20 per cent of the accidents.

These are just the opinions of experts, based on their own particular experiences, and can be said to cover the group of accidents indisputably caused by poor lighting. They would disappear automatically upon the adoption of proper seeing conditions.

Between this 15 to 25 per cent group and accidents in which vision plays no part, is an indeterminate group in

* The reader is referred to the sources of these statements for details of the investigators' reasons for arriving at the conclusion that the difference in visibility was the principal cause of the increase in fatalities.

which light and vision enter in various degrees to cause accidents. Better seeing conditions would not eliminate, but would reduce this group.

One of the obstacles the investigator meets in his efforts to arrive at definite figures in this matter is caused by the unfamiliarity of safety people with visibility phenomena, and their inability to recognize light as a cause in individual cases. Sight and light lie unsuspected under mountains of reports.

There is space in this article to treat only the broad aspects of the light-accident problem, and so individual cases illustrating the way in which poor visibility causes accidents must, of necessity, be omitted. A study of the papers in the bibliography is suggested in this connection.

Lighting literature includes various instances where the accident rate dropped in a department, or even in an entire plant, when the lighting conditions were improved. In one case the average illumination in the punch press department of a company was raised from 2 foot-candles to 19 foot-candles at work level. The frequency of accidents dropped 54 per cent.⁵ This is in line with the rate of drop observed in traffic accidents when visibility is improved.

In another plant a rise to 30 foot-candles from 8 foot-candles caused a drop of 11 per cent in the accident rate. This is reasonable, as this plant had enough general light to provide fair seeing conditions at the original level, and did not, therefore, have so severe an accident rate as the case mentioned previously. By adopting 8 foot-candles originally this plant had saved itself from many of the accidents. The rise to 30 foot-candles simply eliminated the remainder of the "light-vision" accidents that could still occur at the 8 foot-candle level.

R. E. Simpson of the Travelers Insurance Company cites the most striking case. A factory employing 1,000 workers had an annual accident rate of 425. A new lighting system was followed by a drop to 170. In this report the lighting levels were unfortunately not given. An interesting feature of this report is that compensation payments dropped from \$59,500 to \$23,800 annually, which was a saving of nine times the cost of the improved lighting.⁶

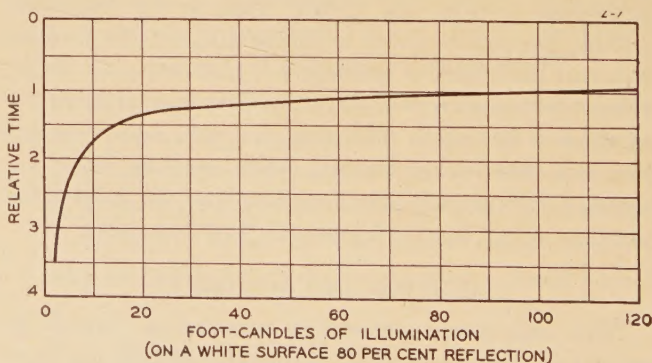


Figure 1. Time and light required for perception

The suggestion may be made that when an industrial plant manager decides to improve the illumination, he may make other improvements as part of the same general program aimed at accident reduction, and that these other conditions may be partly responsible for the ensuing drop in accidents. The experience of the author in connection with over a thousand relighting jobs is that relighting is seldom accompanied by any other change that would affect production, with the exception of changes the lighting engineer may suggest as part of his program for improving visibility, such as painting, changing some machine locations, and tilting surfaces carrying materials undergoing inspection for easier access. In most cases, therefore, the drop in accidents is properly chargeable to the lighting improvement.

The general answer to the question, "What is the relationship between illumination levels and the accident rate?" has been before students of the matter for quite a while, but seems to have been overlooked.

Everyone will agree that if deprived of sight or light and still forced to go about our business we would be certain to have accidents. In other words the relation of visibility to accidents then would be 100 per cent.

Depression experience with reduced street lighting and black-out experience during the war show that accidents average seven times the rate that occurs in the same localities in daylight. That is, under such conditions the accident rate has dropped from the 100 per cent rate with complete lack of visibility to 87½ per cent with slight visibility.

We have here the beginning of a curve showing the relation between lighting levels and accidents, which starts at one end with darkness and all accidents that occur (100 per cent) attributable to lack of light, with the next point on the curve being the amount of illumination somewhere between starlight and moonlight, and an accident rate of seven times the day rate or 87½ per cent.

Now it seems obvious that no amount of light can protect against accidents in which the events move *faster than the speed of vision*, so that the other end of our light-accident curve must be the brightness level at which the speed of vision reaches a maximum. In other words, light as a cause of uncertain seeing can only be a factor in accidents between total darkness and that level of illumination at which speed of seeing ceases to increase. At this point we run into a slight complication. The speed of seeing depends directly on the general or average brightness of the field of view. This average brightness depends, in turn, upon the amount of the illumination present; but, in an interior with dark finishes and dark work materials, the illumination would have to be much more to produce the same speed of seeing that the same illumination could cause in an interior with light finishes.

So the end point of our curve is theoretically placed at that brightness level at which the speed of vision reaches a maximum. Practically, this is of small im-

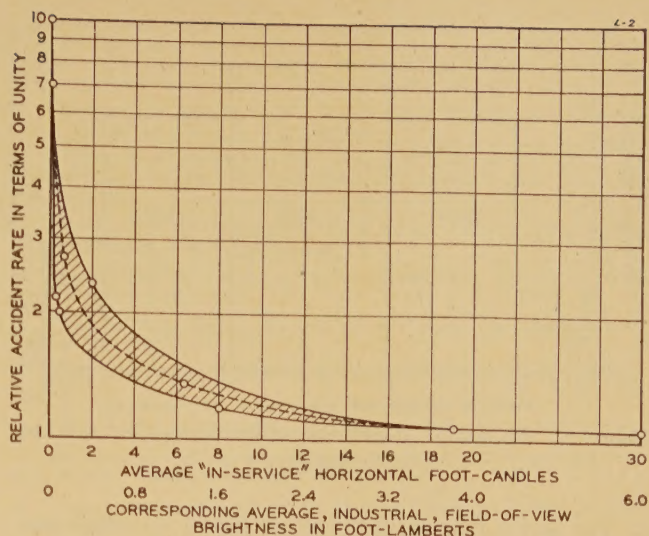


Figure 2. Relation of lighting to the industrial accident rate

Unity represents all accidents having a nonvisual cause

portance as the speed of vision curve has a knee, beyond which it nearly flattens. Past a brightness of 70 foot-lamberts (90 foot-candles on white; see Figure 1), the gain in speed is slight for the rest of the way. Tentatively, therefore, we can end our curve at 70 foot-lamberts.

Knowing the start of the curve, plus its general downward direction (from traffic statistics), and its probable end, only the in-between shape remains to be filled in. Intermediate points can be plotted from the data in this article in the references. The resulting diagram is shown in Figure 2. It stops at 6 foot-lamberts (30 foot-candles in typical industrial interior), instead of 70 foot-lamberts (350 foot-candles in industrial interiors), as it drops only one of the small squares for a distance of 11 times the width of the diagram, beyond the 6 foot-lambert point.

Lighting engineers will note the inverted resemblance of the median line of this diagram to the speed of vision curve. The speed of vision increases rapidly at low levels of brightness. Conversely the rate of accidents decreases rapidly at low levels of brightness. The decrease in accident rate at higher levels slows down just as does the speed of vision.

In basing this diagram on foot-lamberts, the author has made the assumption that the industrial cases reported by investigators concerned plants that had average industrial interior light reflection conditions. The author has determined from a sampling of industrial plants that the average brightness is 20 per cent of the average horizontal illumination (the cases varied from 7 to 30 per cent). This assumption does not affect the shape of the diagram, but only the location of the foot-lamberts reading along the bottom line.

A casual reader may be tempted to judge from the diagram that accidents owing to lighting are only serious at low levels of illumination, but this would be a misreading of the facts. The accident rate is more severe

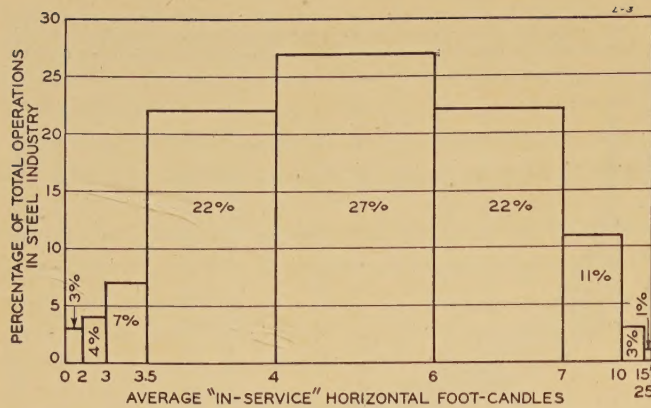


Figure 3. Percentage distribution of illumination levels in the steel industry

at low levels than at high levels but it is sufficiently serious throughout most of the range in which lighting is a factor, to warrant attention.

However, this does raise the question of just how serious "lighting" accidents are, in general, in industry. To answer this question we must know first how lighting and the corresponding brightness levels are distributed throughout industry. We need this knowledge. The writer has had access to such figures for the steel industry. They are plotted in Figure 3, and show for example, that 27 per cent of the operations in the steel industry are performed at illumination levels of from four to six foot-candles, in-service illumination. (This may seem low to the average illuminating engineer, but it is a 100 per cent advance over the comparative figures of nine years ago.) These figures represent lighting installations designed to give from 8 to 15 foot-candles. The difference between the measured and the designed illumination levels is owing to the effects of poor maintenance plus deterioration of the lighting systems. The relative brightnesses are of the order of 20 per cent of these figures.

Looking farther we find that 71 per cent of all steel operations occur at in-service levels of from 3.5 to 7 foot-candles; so it is clear that actual practice, in this industry, at least, is down on the part of the curve in Figure 2 where the accidents caused by lighting conditions are probably from 32 to 60 per cent of the accidents

Table I. Percentage of Light-Caused Accidents in Steel Industry

Percentage Taken from Lighting Levels of Figure 3		Corresponding Percentage Accident Rate from Figure 4	Resulting Percentage of Total Accidents
Foot-Candles	Percentage		
0-2	3	46	1.38
2-3	4	42.5	1.7
3.5-4	22	37	8.15
4-6	27	31	8.4
6-7	22	25.5	5.6
7-10	11	20	2.2
10-15	3	12.5	0.4
15-25	1	7.5	0.07
Total			28.9

from all other causes. These are serious probabilities.

Pursuing the analysis, a curve can be derived from Figure 2 that will show accidents caused by poor visibility, as a percentage of total accidents, throughout the range of the effect of light. This is given in Figure 4 for the most important part of the range. By a comparison of the data in Figures 3 and 4, the probable net percentage of accidents that had a lighting cause, in the steel industry, in 1942, can be computed (see Table I).

That is, the portion of the total accidents in the steel industry, occurring under artificial lighting, that can be probably attributed to uncertain seeing conditions during 1942 is around 29 per cent. This is surely a serious probability, and as we can expect to find a higher figure in industries that are not so well lighted as the steel industry in 1942, the size of the task that confronts the illuminating engineer begins to loom in its true dimensions.

There is another important aspect to this matter. There were 1,600,000 "loss-of-time" accidents to workers, at work, in 1941, according to the National Safety Council. It is customary to record "loss-of-time" accidents on the basis of whether the worker has to go home (or to the hospital) or not. If his injury is such that he can stay at his post, whether he can do effective work or not, it is not customary to list the accident as a "loss-of-time" accident. Neither are accidents to machines, which also interrupt production, listed as "loss-of-time" accidents. Therefore, when we read that 3,000,000,000 man-hours were lost in the 11 months following Pearl Harbor, we are reading only part of the story.

Uncertain seeing conditions are just as effective a cause of "non-loss-of-time" accidents as of admitted "loss-of-time" accidents. It is a fair prophecy that the provision of certain-seeing conditions throughout industry would save at least 200,000,000 man-hours per year, to say nothing of 4,000 worker's lives and 29,000 cripples, 25 per cent of the recorded "at-work" loss.

In conclusion the author wishes to emphasize that the deductions, diagrams, and curves in this article are only educated guesses (with the exception of the speed

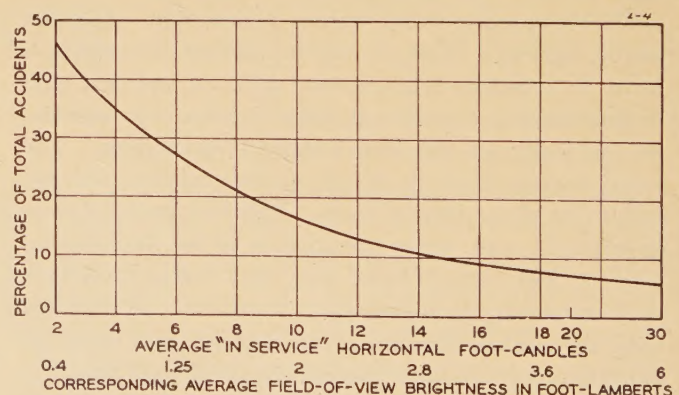


Figure 4. Accidents attributable to lighting causes shown as a percentage of total accidents over the range in which lighting conditions are a cause

of vision curve), but he believes that future statistics will confirm them, and hopes that this study will inspire others to produce the necessary confirmation.

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Three Medals Presented at AIEE Meeting

PRESENTATION of three of the highest engineering honors—the Edison, John Fritz, and Hoover Medals—to three engineers in vastly different fields of the profession, at a special session of the AIEE national technical meeting on January 27, 1943, was unique in the history of the Institute. Research has revealed that at no time previous to this have three such signal honors been conferred at one AIEE ceremony. The 1942 Edison Medal, highest award of the AIEE, was presented to Edwin Howard Armstrong, professor of electrical engineering, Columbia University, New York, N. Y. Willis R. Whitney (A '01), vice-president in charge of research, General Electric Company, Schenectady, N. Y., was awarded the 1943 John Fritz Medal, given for notable scientific or industrial achievement. The award of the 1942 Hoover Medal, honoring an engineer for distinguished public service, was made to Gerard Swope (F '22), president of the General Electric Company, New York, N. Y. Text of presentation addresses and responses of medalists follow (*EE*, Mar. '43, pp. 116–17).

E. H. Armstrong—Edison Medalist

ALAN HAZELTINE, Fellow AIEE

IF we review the advances in electrical technology in the past 25 years, one development stands out from all others, electronics, and specifically the application of

the three-electrode vacuum tube. It is appropriate to recall here that the original electronic tube was the two-electrode tube of Edison, in whose honor the Edison medal was established. Others subsequently applied this "Edison effect" in radio detection and introduced the control electrode, but the action was viewed as that of a trigger, as in the modern thyratron, which is of limited application. The real foundation for the unlimited development which we have witnessed was laid by the Edison Medal recipient, Doctor Edwin Howard Armstrong, in an article published in the *Electrical World* in December 1914. Here the common engineering tool, the characteristic curve, was employed for the first time to show how the tube amplifies; and the theory was substantiated by oscillograms which Armstrong had taken. The previously mysterious action of the tube as a rectifying detector with a grid capacitor was elucidated in the same way.

I well remember the impression this article made upon me at the time, and the conviction that here was something with great possibilities. I also remember the excitement produced a few months later by Armstrong's first paper before the Institute of Radio Engineers on his feed-back circuit, which employed this theory to give undreamed-of amplification of weak radio signals and permitted the general use of heterodyne reception by providing for the first time a source of continuous oscillations of frequencies as high as any then used for radio

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transmission. May I take this occasion to note that these publications of Armstrong started my own work in radio and profoundly affected my subsequent career, as they have affected the careers of many others?

It is rather hard now to take ourselves back to conditions in radio prior to Armstrong. Attempts were being made at transoceanic telegraph communication, but with only very restricted success, even with enormous receiving antennas and elaborate commercial apparatus. The radio amateurs, who shortly were to be the mainstay of Signal Corps and Navy radio in World War I and were later to supply the radio engineering talent called out by broadcasting, could receive only local signals. Armstrong's work removed the barrier to regular long-distance radio telegraphy. By increases in power of the vacuum tubes, it also provided an easily modulated high-frequency source for radiotelephone transmitting, so that long-distance radiotelephony soon followed. And then came the great broadcasting development with its far-reaching social consequences.

The early work of Armstrong, the experimental part of which was done while he was still an undergraduate at Columbia University, soon received recognition. Its importance was appreciated by Professor Pupin, who took Armstrong under his wing. Together they carried on several researches in radio. In 1917 the Institute of Radio Engineers awarded its Medal of Honor to Armstrong for the feed-back circuit, the presentation being made by Professor Pupin, then president of that society. I recall a remark of Professor Pupin on that occasion: that inventions are sometimes ascribed to luck, but that the best luck is to have a good head on one's shoulders! The correctness of Pupin's appraisal has been demonstrated amply by Armstrong's subsequent career.

In this period, the question of amplification due to heterodyne reception was in dispute. Armstrong clarified the matter in a paper presented to the Institute of Radio Engineers in 1916. Doubtless this study paved the way for Armstrong's next important invention, the super-

heterodyne receiver, although Armstrong himself attributes it to the luck of a chance conversation in which were pointed out the limitations to the amplification feasible at the higher frequencies. Armstrong changed the wave frequency to a lower intermediate frequency by heterodyne action, using his vacuum-tube oscillator, and then carried out further amplification at this intermediate frequency. This method was developed for military purposes during World War I, while Armstrong was an officer in the Signal Corps in France. Now it is employed almost universally in radio reception.

Armstrong never abandoned his first love, radio. After the war, he returned to his laboratory researches at Columbia; and here, in an experimental set-up for another purpose, he happened to notice an extraordinary amplification of a locally generated signal. Ninety-nine out of one hundred experimenters would have failed either to notice the effect or to find its cause. But Armstrong's characteristic persistence and ability to analyze physical phenomena tracked down the demon; and superregeneration was added to the radio art. Although it was not of such wide utility as Doctor Armstrong's other fundamental inventions, it was found essential in pioneer work at ultrahigh frequencies and now is applied to certain military purposes.

By this time, we were in the era of broadcasting. Some of the best analytical brains had been directed to the theory of radio. It seemed that all the foundations had been laid, that no new fundamental methods were to be anticipated. Frequency modulation had been considered, used to some extent, and then discarded. The

fallacy of using it to narrow the band of transmitted frequencies had been exposed. It was rejected as useless and even harmful. But Armstrong had other ideas. By going contrary to accepted notions and greatly widening the range of frequency variation, he developed a system of frequency modulation ideally suited to broadcasting, which was announced only in 1936. Although

AIEE Edison Medalists

1909	Elihu Thomson	1927	William D. Coolidge
1910	Frank J. Sprague	1928	Frank B. Jewett
1911	George Westinghouse	1929	Charles F. Scott
1912	William Stanley	1930	Frank Conrad
1913	Charles F. Brush	1931	E. W. Rice, Jr.
1914	Alexander Graham Bell	1932	Bancroft Gherardi
1916	Nikola Tesla	1933	Arthur E. Kennelly
1917	John J. Carty	1934	Willis R. Whitney
1918	Benjamin G. Lamme	1935	Lewis B. Stillwell
1919	W. L. R. Emmet	1936	Alex Dow
1920	Michael I. Pupin	1937	Gano Dunn
1921	Cummings C. Chesney	1938	Dugald C. Jackson
1922	Robert A. Millikan	1939	Philip Torchio
1923	John W. Lieb	1940	George Ashley Campbell
1924	John W. Howell	1941	John B. Whitehead
1925	Harris J. Ryan	1942	Edwin H. Armstrong

facing the tremendous handicap of an established broadcasting system, with thousands of transmitting stations and many millions of receivers in use, none of which could employ it, it already seems destined largely to supplant the conventional amplitude modulation. The two great limitations in amplitude modulation were the noise accompanying the signal and the interference between stations on neighboring frequencies, so that over a large area two stations would spoil each other's programs. Wide-range frequency modulation enormously improved the signal-to-noise ratio and almost eliminated the area over which stations on neighboring frequencies would interfere. Besides, the use of ultrahigh frequencies, essential in this system, made it feasible to cover a wide audio-frequency range, with great improvement in the fidelity of reproduction.

Of course, Armstrong has made many other discoveries and inventions. Specific oscillating circuits commonly associated with other names were among those which he was the first to study. In his early work with Pupin, he considered a regenerative vacuum tube as a controllable negative resistance or reactance element; and he made laboratory measurements of these properties. But the time was not ripe for the present-day applications such as automatic tuning.

Not only has all of Armstrong's work been built on the electronic vacuum tube originating with Edison, but his most evident characteristic has been that for which Edison was famous—pertinacity. I can testify that mealtime means nothing to Armstrong when his mind is set on a technical matter; this must be settled first, even though an after-dinner discussion would have been as effective! But it is just such concentration that has been needed to carry through his discoveries and developments.

There is another characteristic of Armstrong which is not so immediately evident: He is mathematical, because all of his results, no matter how he was first led toward them, were ultimately put in logical exact form. He is not known for the discovery of new scientific facts, nor for the creation of new structures. His discoveries were methods—new ways of doing things. Let us draw a parallel: The true father of electrical engineering was Faraday, who laid a new foundation for every branch of electrical science and whose concepts are the working tools of the electrical engineer. Because no algebraic equations appear in Faraday's writings, he has been viewed simply as an experimental physicist. But Pupin, appreciating the exactness of Faraday's reasoning, has pronounced him a great mathematician. It is so with Armstrong, who shies when you talk to him with equations, but who reasons clearly and accurately in the many-dimensional field of physics, rather than in the one-dimensional field of algebra and calculus. It may be significant that in Pupin's old office, which Armstrong now occupies, there hangs one picture each of the famous pioneers of electrical science, but there are two

pictures of Faraday. Armstrong also is an inspired mathematician.

Vagaries and Elusiveness of Invention

EDWIN H. ARMSTRONG

IT is not possible for me to find the words to tell you what this honor means to me. To have belonged to the generation which learned the meaning of volts and amperes when Edison was at the height of his career, to be able to follow in the footsteps of my old instructor—Michael Pupin—who stood here 22 years ago, and to have my own work appraised, during these difficult days, as worthy of the Edison Medal, gives it an inspiring meaning that can never be described.

But on an occasion such as this, when a man looks back over the events associated with his work, there come some sobering second thoughts. For he begins to realize how minor is that part which he himself has played in shaping the events of his career, how overpowering the part played by circumstances utterly beyond his control. The continuous good fortune which has followed me, providing second chances at inventions when the first chance was missed and tossed away, has been all that a man could hope for and more than he has any right to expect.

Only the invention of regeneration and the system of frequency modulation were the result of any conscious effort on my part to solve a definite problem. One problem was attacked on no theory at all except that something must be wrong with the existing one; the other problem was attacked by a method of reasoning that was to turn out to be just 100 per cent wrong. And in each case, a chance observation in the laboratory was to lead to the discovery of principles the existence of which I never had the remotest idea.

These occurrences, however, must be considered as the outgrowth of quite ordinary and conventional research in the light of the chain of circumstances which were to lead to the discovery of the superheterodyne and super-regenerative principles. One of these was to come from a war, the other from a legal proceeding.

I am most highly flattered by the reference which my good friend, Alan Hazeltine, has made to any ability of mine in the realm of the mathematical way of thinking. The fact is that the first step in the chain of events which was to lead to the superheterodyne invention came about because I could not understand the mathematics used in the dispute he has referred to, and I had to make

a long experimental investigation to clear it up. This investigation gave me for the first time a clear understanding of the nature of the heterodyne. These results were published shortly before I left for France for service in the Signal Corps in the American Expeditionary Forces.

Shipped via England, I arrived in Southampton, and there came the second link in the chain of good fortune. Bad weather was to close the English Channel for three days and give some of us the opportunity to go to London and see the town. There I chanced to meet Captain Round of the British Army Intelligence Service and from him learned of one of the most important problems of the war, the reception of very weak signals of what then were considered to be "short" wave lengths. He outlined the highly ingenious steps which already had been taken along conventional lines, but as they involved the use of special vacuum tubes which we did not have, it was clear that the problem as far as the United States forces were concerned was one for the base laboratories. The information was duly forwarded to the United States.

The third link came months later as I happened to be watching a night bombing raid and wondering at the ineffectiveness of the anti-aircraft fire. I may say that night bombing was not very dangerous in those days, either for the man on the ground or the man in the airplane. Thinking of some way of improving the methods of locating the position of the airplanes, I conceived the idea that perhaps the very short waves sent out from them by the motor ignition system might be used. The unique nature of the problem, involving the amplification of waves shorter than any ever even contemplated and quite insoluble by any conventional means of reception, demanded a radical solution. All three links of the chain suddenly joined up and the superheterodyne method of amplification was practically forced into existence. Not one link in the chain could have been dispensed with. This, I think, is the only completely synthetic invention I have ever made.

The superheterodyne was never used in World War I for the purpose for which it was invented. A more important use for it then was found. But it is interesting to note that it is one of the indispensable elements of an aircraft-detection scheme of the present

war which operates on a much more practical principle.

Seldom can an inventor look philosophically upon the bane of his existence, patent litigation, and find much good therein. He might as well be expected to become philosophical about the serpent in the Garden of Eden. Yet the superregenerative circuit was to be discovered as a direct result of a legal action in which the regenerative circuit became involved shortly after World War I. During these proceedings it came to pass that counsel for

the opposition made denial of some fundamental truths. Such behavior is not entirely unknown in courts presided over by even our most learned judges, nor can it be said to be entirely unsuccessful.

To furnish a convincing answer, I set up demonstration equipment involving some measurement apparatus that included a regenerative circuit. These instruments were all placed on a table in the Marcellus Hartley Research Laboratory at Columbia University and arranged to receive from a miniature transmitter across the room, and were quite dissociated from any antenna or ground connection. While I was adjusting the receiver to re-

spond to signals from the miniature transmitter, other signals of a most unusual character suddenly came in. The first thought was that a British cruiser was nearby in the North River, since the tone of the telegraphic signal was somewhat akin to their characteristic double-tone spark note and the strength so remarkable. It was then observed from the character of the messages that the signals were coming from the Brooklyn Navy Yard. Other well known stations also came in with a strength hundreds of times that which any regenerative circuit would give. As it gradually dawned upon me that some new principle of amplification was being observed, the nature of which I could not even guess, the effect disappeared and could not be reproduced. Only the comparatively feeble response of a simple regenerative circuit was left, and nothing I did would make it behave in other than its quite conventional manner.

Five minutes before I would have sworn to the high heavens that I understood all there was to know about regeneration. Five minutes only were required to wipe out that complacent belief engendered by nearly a decade's work with the subject. Some completely bewildered experimentation eventually restored the strange effect,



Edwin H. Armstrong, 1942 Edison Medalist

and finally I learned how it could be maintained long enough to examine it. And then it only remained to find out what it was all about and discover the principle of operation. A little work brought to light a principle quite beyond the bounds of one's wildest dreams. Its existence had never been suspected, in any way and it is doubtful if it could ever have been evolved by analytical means. Professor Hazeltine, who helped me over the high spot in one of the obscure phases of this theory, will, I think, bear me out.

Much of what I have said is already well known, but there is one chapter in the history of superregeneration which has never been published. It was not known to me until a few years ago.

Five years before the events which I have just related took place, I set up and operated what I now know to have been a superregenerative circuit. Because of the particular conditions under which it was used, the superregenerative effect was not manifested outstandingly. I missed it, ascribing the operation of the circuit, which was somewhat better than expected, solely to the effects of ordinary regeneration. The arrangement was published in my original paper on regeneration in 1915, described as a regenerative circuit, and the paper was translated into many languages and went to the four corners of the globe. No one apparently saw anything more in it than I. Nearly 20 years later, while looking idly through this old paper, recollection of some of the effects observed brought the startling thought that I must have then had and missed superregeneration. The original apparatus, which was still intact, was set up and put into operation again and it superregenerated beautifully! It is seldom that one avoids the penalty for a blunder such as this.

I have related here a story of events that good fortune alone could bring about, but I do not want to create the impression that one's guardian angel always acts so promptly. The chance observation in the case of the frequency-modulation system was delayed for nearly 20 years while a course of what I, at least, considered reasoned effort led to a chase of more will-o-the-wisps than I ever thought could exit. It takes a long time to learn the lesson that reasoning sometimes cannot give the answer.

There has grown up through the years a school of thought that is coloring some of the recent legislative proposals dealing with invention, which holds that invention can be reduced solely to a basis of logic and reasoning. I wish I could persuade them to explain to me the system; it would save an enormous amount of trouble. I have never been able to do it, except afterward. For the disciples of that school I would suggest just a few years apprenticeship in a laboratory, working on what we would today term an "insoluble" problem. Daily contact with the laws of nature has a way of keeping a man's feet on the ground.

I have tried to describe the effect that circumstances

quite out of my control had to do with the making of these inventions. I wish it were possible to describe here also that part played by my old instructors and those who have assisted me through the years. Here also I have had extreme good fortune. For the moment I can only echo the thought expressed by the recipient of the Edison Medal last year, that he wished the names of those who had helped him attain it could be engraved upon it, and say that whenever I look upon this award, I shall always see their names around it.

Willis Whitney—John Fritz Medalist

DAVID C. PRINCE, Fellow AIEE

IF you should pick up a turtle five miles or so from Schenectady, N. Y., and find markings on his shell—a date and the letter *W*—you would note the time and place of your discovery and notify Doctor Whitney; you and the turtle then would be participating in scientific research. Down on the island of Nassau there are conch shells that show markings and pictures through their opalescent linings. They have been in Doctor Whitney's hands and he has made these markings to study the mechanism of shell growth.

I suppose as a boy in Jamestown, N. Y., he poked around the beaches of Lake Erie and the neighboring woods, picking up sticks and stones and throwing them at trees or in the water. Then he came to know Mr. William Hall, a neighbor. Mr. Hall was a naturalist as well as a businessman. He had a microscope and made his own slides. He showed these to the boys in the evening after school. A new world was opened to Willis Whitney. Things were not what they seemed to the naked eye. They had fine-grained structure. Why?

The Whitneys gave Willis a microscope of his own. He made sections and tried to find out for himself how the world was made.

He went to the Massachusetts Institute of Technology in 1886 to learn more of the composition of nature. Biology, electrical engineering, and chemistry all attracted him. He chose chemistry but his curiosity has never been confined to a narrow beam. Biology and physics have shared his interest in chemistry and anything else that came before him.

He went to the University of Leipzig to study under Wilhelm Ostwald. There he received the degree of doctor of philosophy. He studied for a short time at the Sorbonne under Charles Friedel. Then he returned to Massachusetts Institute of Technology to teach and investigate on his own account. Gerard

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Swope was one of his students.

He found that rusting was produced by iron going into solution in pure water by replacing hydrogen ions which are deposited as gaseous hydrogen on the metal. If oxygen is dissolved in the water it reacts with the hydrogen, removing it from the surface and allowing the rusting to proceed. He experimented with other phenomena and declined offers of jobs outside the Massachusetts Institute of Technology because he feared they might restrict the opportunities for research.

In 1900, Mr. E. W. Rice, vice-president of the General

Electric Company thought of forming a research organization for the company. He reasoned that the electrical industry was based on the discoveries of scientists like Faraday and Maxwell, that more discoveries were sure to follow, and that the growing industry should have the benefit of them.

Other industries had laboratories. They tested materials to be sure that they came up to specifications. They were called in to investigate unexpected difficulties but they did not investigate the unknown as such. Mr. Rice wanted a laboratory to carry on research in pure science. He invited Doctor Whitney to organize such a laboratory.

In spite of Mr. Rice's assurances, Doctor Whitney feared that he would not be free to select his own subjects of research, he questioned whether there would be enough worth-while problems in the electrical industry.

Finally after consulting Professor Elihu Thompson, Doctor Whitney agreed to work part time in Schenectady, associated with Doctor Steinmetz. Doctor Steinmetz was showing how the work of Faraday and Maxwell could be interpreted quantitatively in the design of actual motors and transformers. Doctor Whitney shared an assistant and a barn behind Steinmetz's house for three weeks until the barn burned. Then he was assigned a small building in the factory and the research laboratory was born, although it was not until 1904 that Doctor

John Fritz Medalists

1902	John Fritz	1925	John F. Stevens
1905	Lord Kelvin	1926	Edward D. Adams
1906	George Westinghouse	1927	Elmer A. Sperry
1907	Alexander Graham Bell	1928	John J. Carty
1908	Thomas A. Edison	1929	Herbert Hoover
1909	Charles T. Porter	1930	Ralph Modjeski
1910	Alfred Noble	1931	Admiral David W. Taylor
1911	Sir William Henry White	1932	Michael I. Pupin
1912	Robert Woolston Hunt	1933	Daniel C. Jackling
1914	John E. Sweet	1934	John Ripley Freeman
1915	James Douglas	1935	Frank J. Sprague
1916	Elihu Thomson	1936	W. F. Durand
1917	Henry Marion Howe	1937	Arthur N. Talbot
1918	J. Waldo Smith	1938	Paul D. Merica
1919	George W. Goethals	1939	Frank B. Jewett
1920	Orville Wright	1940	C. F. Hirshfeld
1921	Sir Robert Hadfield	1941	Ralph Budd
1922	Eugene Schneider	1942	Everette DeGolyer
1923	Guglielmo Marconi	1943	Willis Rodney Whitney
1924	Ambrose Swasey		

Whitney was satisfied that it offered him a full time job.

In the early days of the research laboratory Doctor Whitney did most of the work himself. The metalized carbon filament, first big advance in incandescent lamps beyond the point reached by Edison, was made by Whitney. He developed ceramic-type high resistance rods for early lightning arresters and arc electrodes. Other scientists—Coolidge, Langmuir, Hull, and many others—were attracted to the laboratory. Doctor Whitney continued his own researches but was always

glad to turn over a good lead to one of his younger associates who would get all the credit for any good that came of it. For all of them he maintained a friendly atmosphere in which apparatus and free advice and interchange of ideas were encouraged.

Outside scientists visited the laboratory constantly and were introduced to the laboratory staff through colloquia where developments inside and outside the laboratory were freely exchanged. Publication of all scientific findings at an early stage was always encouraged. Doctor Whitney believed that for every idea he gave away he would get two back.

It may seem a far cry from the wanderings of turtles to Langmuir's investigations of monomolecular layers but the fundamentals are the same. An observation is made, an hypothesis is constructed. Tests are initiated to prove the hypothesis or serve as the basis for a new hypothesis. It may seem a far cry from sharing one assistant and a barn with Doctor Steinmetz to sharing the facilities of a great laboratory with a hundred staff members and scientists of the world at large, but again the principle is the same.

In recognizing the value of the combination of these two elements so essential to our modern world, the John Fritz Medal Committee should be honoring both the recipient and the memory of the man for whom the medal is named.

Engineering Research

WILLIS R. WHITNEY, Associate AIEE

WHEN I consider the work of the former recipients of the John Fritz Medal, I see clearly that I am not one of those sturdy individualistic pioneers of engineering but rather, a well-protected product of organization, a representative of a group of supported scientific workers. This greatly increases the satisfaction and honor which I feel in this event.

After many years as director of research, I realize that usually I did not direct anybody or anything. A director merely points like some wooden arrow along the highway. Research directing is following the openings of acceptable new ideas. It is watching the growth of thought in the minds and hands of careful investigators. Often even the lonely mental pioneer, being grubstaked, advances so far into the generally unknown, that a so-called director merely happily follows the new ways provided. All new paths both multiply and divide as they proceed, so with much random direction there would be danger of getting lost.

During the major period of American enterprise, the engineer was not only the discoverer of new needs, he was forced to be also the experimenter, developer, and procurer of necessary financial support. Such have been most of the eminent recipients of the John Fritz Award. Anyone knowing the pioneering engineers of our early days, knows many who suffered privation and made all sorts of sacrifices to promote their ideas. There was no way of knowing the promise of some novel idea or of some energetic engineer.

As industries expanded with the growth of the United States, engineers became regular employees of the large organizations. The works of mining companies, railroads, city and federal governments, and manufacturing in general were directed by permanently employed engineers. As engineers increased in number in scientific societies and individual industries, the helpful effect of one mind on another, the group support, became evident. Then the risk of new undertakings was reduced, so that large organizations could advance safely. As a result of the expansion of industries so that thousands of employees were concerned, the danger of product obsolescence became acute, and there was the threat of large numbers being thrown out of employment by some im-

provement in the industry. All engineers aimed at newness and product betterment, and so anyone might suddenly disrupt a group of workers by some alteration of product or process.

The research laboratory of the General Electric Company was a development of the idea that large industrial organizations have both an opportunity and a responsibility for their own life insurance. New discovery can provide it. Moreover, the need for such insurance and the opportunity it presents, rise faster than in direct proportion to the size of the organization. Manufacturing groups could thus develop their continuity beyond that of the originator, because the accumulated values of knowledge and experience became gradually recognized. No one yet knows the possible longevity of a properly engineered manufacturing system. Research has become engineering support.

Research is expensive. No one knows exactly how much an industry should spend on research. Clearly, a small, one-product company could scarcely afford even a full-time researcher; yet individual and small companies have been successful. Emerson's mousetrap comes to mind. Certainly the fellows who still make the red-stained, four-hole, wooden mousetrap must have sought new knowledge so that after so many years it can still hold its own.

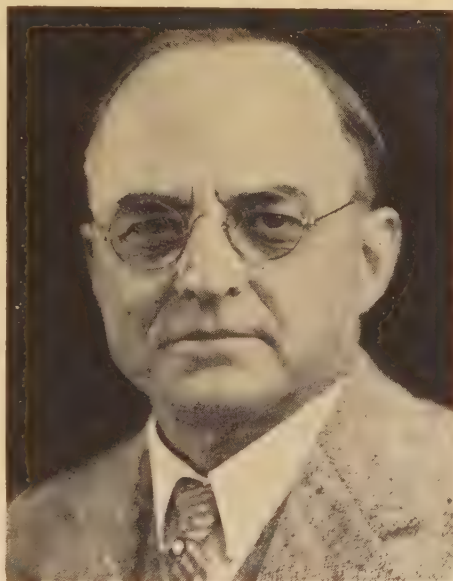
I once looked forward to trying to get the General Electric Company to expend regularly one per cent of profits on the pure science. I look back and wonder why I ever aimed so low. I have such confidence in the still unknown, such faith in American curiosity, and such a conception of the exponential possibilities of new efforts that I would temporarily greatly reduce dividends in order further to insure permanence.

I sometimes think poets express truth better than scientists do. In the "Testament of Beauty" of Robert Bridges, formerly poet laureate of England, are these

words: "Conduct lies in the masterful administration of the unforeseen."

Our industrial "unforeseen" is made up of new liabilities and new assets. What we don't yet know, we must still administer masterfully if we want to survive. It may be contradictory to use the "unforeseen" in illustrations. But old facts may be extrapolated. A live industry is always engineering new or better products.

The General Electric Company's laboratory of scientific research was established by the voice of engineers under the leadership of their chief, E. W. Rice in 1900.



Willis R. Whitney, 1943 Fritz Medalist

I think he felt that the new electrical industry could be unlimited if proper foresight were used. He also saw that at any one instant all the engineers were absorbed by pressing calls, trouble shooting for improvement and economies of established products. There should be an incubator of unborn ideas to be generated by discoveries in the purely scientific core of electricity. Thus aid would be given engineers, through the electrical curiosity of experimenters in any part of the field. He hoped to keep his electric company co-operating even if the demand ceased for some of its current products.

He wanted actual search for new truth about electricity and so introduced to cost of production a new kind of industrial overhead. Discoveries were not merely desirable end points, but were starting points in an infinite field of electrical service. The process could be self-perpetuating. We have all witnessed ends of many profitable undertakings in electricity where the recovery of commercial activity was successfully cultivated in quite new electrical fields. Such activity as production of carbon incandescent lamps, carbon arc lamps, and so forth, peacefully passed away without excessive hurt. Some unforeseen undertakings in electronics could provide the cure.

At no time in history was there such a great mass of the "unforeseen" available to us. This applies to every bud and tip of countless branches in the forests of trees of knowledge. These can never die and they await appreciation.

I have thought of this in connection particularly with modern chemistry and the new electricity, but it applies as well to all our mental activities. We still fail to realize our possibilities.

The experience of organic chemistry was repeated in electrical science. The new field seems infinite again. There is room enough here for a world of scientists. Certainly some of the slack of postwar depression may be taken up through new knowledge.

I have lived to see that bothersome "Edison-effect" of vacuum lamps develop into the boundless areas of electronics. Hard, round, indivisible atoms, of centuries' endurance, began to emit some of their components. Nothing could have been more "unforeseen" than that. And now photographs of some of those organic chemical molecules are actually made without light, by electrons which give us a magnification scores of times higher than was ever optically possible. The wildest imagination never foresaw what has actually come from this truly "unforeseen."

In summarizing advances in practical electronics, I like to compare the electron with Archimedes' lever. Electrons do their work by using imaginary dimensions and almost nothing for the levers. The length, the fulcrum, and the material have disappeared. Disembodied electrical power itself is guided by unhuman electrical senses. Resembling our human senses, they are much more exact and tireless. The power of screws, the use of

wheels, hydraulic rams and presses, pulley blocks, belts and trunnions, and races of ball bearings came directly from the principle of the lever. Certainly one could lift the world if a fulcrum were ready. Perhaps the same should be said of the electron. Employed first for speaking, hearing, seeing, smelling, tasting, and feeling, it can record its findings and it can also present its records at any time in any part of the world. It can use a sub-conscious integrating entity for directing and controlling any amount of power while performing any kind of work at any desired rate.

The strange thing about it is that this is all done, not by "mirrors," but by next to nothing in a vacuum.

Electronics seems to me as extensive and promising a new science as the whole of electricity seemed but a few years ago.

Gerard Swope—Hoover Medalist

KARL T. COMPTON, Fellow AIEE

GERARD Swope is presented for the Hoover Medal on the ground of his "constructive public service in the field of social, civic, and humanitarian effort." One of his humanitarian efforts has been to help me on many occasions in the consideration of measures for improving the educational work of the Massachusetts Institute of Technology, of which he is an executive committee member.

I attempt to summarize some aspects of the constructive public service for which this medal is awarded with some misgiving as the result of a dinner conversation which I had last night with the head of one of the divisions of the General Electric Company. He told me that the first thing which struck him about Gerard Swope was his impatience at having to waste valuable time listening to statements about matters on which he was already informed.

As the setting for the particular achievements recognized by this award, turn briefly to Gerard Swope's engineering and business career. It was two years before his graduation in 1895 as an electrical engineer from the Massachusetts Institute of Technology that he was first employed by the General Electric Company in the humble rank of "helper." At the Massachusetts Institute of Technology one of his instructors was Doctor Willis R. Whitney. I had a very interesting letter from Doctor Whitney apropos of this occasion, in which he described his very favorable impression of Gerard Swope as a student, and his equally favorable impression of Gerard Swope as his chief later on. As a student he remarks that, as he recalls it, Gerard Swope was not one

Karl T. Compton is president of Massachusetts Institute of Technology, Cambridge.

of the group which attached the compressed air to the gas mains. As a chief, he remarked that looking back on the efforts which he had made and the many discussions he had had with Mr. Swope in regard to the increasing of the research facilities of the General Electric Company, he was inclined to feel that any lack of securing even more support than he did secure was due to his lack of imagination and failure to present the case rather than to any withholding of support by his chief.

After graduation from the Massachusetts Institute of Technology, he went to work in the shops of the Western Electric Company and shortly thereafter became manager of the branch in his boyhood home city of St. Louis, Mo. Then after two years in the Chicago (Ill.) Division, he came to New York as general sales manager of the company in 1908, and five years later he became vice-president and director.

In 1919 he left the Western Electric Company to become president of the International General Electric Company. A sentimentalist might say that this was going back to his first love and suggest that it was the consummation of day dreams which may have passed through his mind during his career as helper 26 years earlier with the General Electric Company, but I have heard a much more realistic explanation from one of his former colleagues in the Western Electric Company to the effect that Swope so outgeneraled his General Electric competitors year after year that, unable to beat him, they had to elect him their own president.

However this may be, he became General Electric Company's president in 1923, resigning from this position in 1940, but he was called back to it in September 1942 in order that his successor, Charles E. Wilson, might accept the vice-chairmanship of the War Production Board.

His career as electrical engineer, commercial engineer, and industrialist has brought him distinction and a good living. But in so far as the Hoover Medal is concerned, this industrial career has given setting and opportunity for what we in academic circles call extracurricular activities—activities which go beyond the minimum requirements of the job, though usually constructively related to it. Therefore, I am going to suggest some of the present medalist's interests which are typical of those for which the Hoover medal is awarded.

In the field of economic leadership little need be said. Though of very great significance, Gerard Swope's accomplishment in this field is obvious. The administration of a great industrial organization in such manner as to give the public more and better services and products at less cost, to build up the loyalty and

Hoover Medalists

1930	Herbert Hoover
1936	Ambrose Swasey
1938	John F. Stevens
1939	Gano Dunn
1941	D. Robert Yarnall
1942	Gerard Swope

self-respect of the members of the organization, to satisfy the stockholders, to inaugurate policies designed to stabilize the business through good times and bad, yet flexible enough to meet new situations successfully; to be ever on the alert to seize opportunities for technological or social improvement—such administration in itself is economic leadership of high order. Such leadership Gerard Swope has

displayed throughout his career.

I think the basic reason for his success in this field is disclosed in a comment by the one who knows him best, his wife. She remarked that, "He has always thoroughly respected his job, . . . believing that industry, which touches so many lives, is a most important part of our society."

I can do no better in introducing the next comments than again to quote Mrs. Swope, at the same time mentioning that she has shared his intense interest in humanitarian affairs ever since they first met in connection with the activities of Hull House in Chicago and under the influence of Jane Addams. Mrs. Swope has told me that her husband "has always been more interested in civic and social projects and aims than in the purely philanthropic which, rightly or wrongly, seem to him less constructive."

I have, myself, observed his keen combination of hard-headed practical good sense and altruistic purpose. For example, he has long had a strong desire to help deserving young people to secure an education. But he does not approach this by the easy way of giving them money, except perhaps as an occasional incentive in the form of a prize. He has also been concerned with the financing of educational institutions in which he has been interested, but again his normal approach is not in the easy and limited manner of a gift. Instead, for example, he combined all these objectives in a constructive manner by raising a large loan fund, available to deserving students and administered in businesslike fashion so as to be perpetually revolving. This aids the student, justifies the institution in charging a substantial tuition, and hence aids the institution, and yet is devoid of the element of charity. Except for the original donors of the fund, it is a strictly business proposition on all sides, payment for value received but under most helpful circumstances.

On a much more important scale, these same principles were embodied in Gerard Swope's very important contributions toward the solution of problems of unemployment and stabilization of industry. On these problems he worked with great zeal and effectiveness, especially during the early 1930's when the public was generally bewildered by the tragedy of the depression. Characteristically thinking ahead of the majority of his

fellows, he was ready with constructively thought out proposals, and by his leadership and stimulation, did an enormous service in helping to mold the thinking of businessmen, labor leaders, and the general public.

This industrial relations situation is complicated by forces of prejudice, politics and selfishness, as well as of scientific logic. It is not strange, therefore, that the Swope plan of unemployment insurance or the Swope plan of industrial stabilization have not been adopted just in the form in which he proposed them. Yet it is certainly fair to say that the plans now in force under such auspices as, for example, the Social Security Act, are far better plans than we would have had except for the ideas and stimulus contributed by Gerard Swope. Also, all through the ranks of industry, labor, and government are officials whose sympathetic understanding of problems of employer-employee relations and industrial stabilization is based directly or indirectly on the organized thinking of which his contributions were so significant a part.

But to get back to Swope's basic attitude in these matters, take the case of unemployment benefits. He did not like any system of doles or handouts, either from industry to its workers or from government to its citizens. He believes that such expedients are not only not constructive, but that they are positively demoralizing. But he does believe in giving help generously where the person helped co-operates in the effort, and provided it is done in such manner as will tend to create conditions reducing the necessity for help in the future.

For example, his unemployment-insurance plan adopted by the General Electric Company provided joint contributions to the reserve fund both by company and employees. Thus, to protect the fund and to reduce the size of their contributions to it, both parties have a financial incentive to run their affairs so as to keep unemployment at a minimum. He disapproved a state plan which proposed simply to pool all contributions from employers, on the ground that this would detract from the financial pressure on each individual employer to run his own business as stably as possible, and also on the ground that this would force one employer to pay part of the costs of careless employee management by another.

Thus, throughout Gerard Swope's altruistic idealism, we see a clear pattern of shrewd business judgment and fundamental fairness. This element, combined with his absolute unselfishness and intense desire to improve human society, are, in my judgment, the foundations of his work which have led to the award of the Hoover Medal.

I am conscious of my inability to present here any adequate portrayal of a man of such energetic and varied accomplishments. I have, therefore, tried to give only some scattered glimpses of the man himself. But to suggest how much more remains unsaid, I am going simply to recount a list of some of his public commissions.

Going back to his early days only a few years after his graduation from college, Gerard Swope served on the Playground Commission of St. Louis and was chairman of the Public Bath Commission of St. Louis. Then during World War I, under General Goethals, he was assistant director of purchase, storage, and traffic on the general staff of the United States Army, for which he was awarded the Distinguished Service Medal. Then coming into the times of the early depression, his public services included the following:

Industrial Advisory Board of the National Recovery Administration.

Chairman of the Business Advisory and Planning Council, under Secretary Daniel Roper.

Chairman of Coal Arbitration Board.

President's Advisory Board on Economic Security.

First National Labor Board.

First president of the National Electrical Manufacturers Association.

Advisory Council on Social Security.

Chairman of the Industrial Relations Commission to Great Britain and Sweden.

Chairman, Eighth American Red Cross Roll.

Chairman of the National Mobilization for Human Needs.

Member of the Corporation and Executive Committee of Massachusetts Institute of Technology.

Member of visiting committee of Department of Astronomy of Harvard University.

Past president and director of Greenwich House, New York, N. Y.

Council on Foreign Relations.

President, Westchester County Park Commission.

Taconic State Park Commission.

Chairman, New York City Housing Authority.

Assistant to the Secretary of the Treasury.

Chairman, National Budget Committee for War Appeals.

Excerpts from letters received following the announcement that Gerard Swope was to receive the Hoover Medal further bear out the fact that his choice as recipient was highly merited. The first from Daniel Roper follows:

"I am glad to learn that you are to make the presentation address on the occasion of the award of the Hoover Medal for 1942 to our mutual friend, Gerard Swope.

"Nothing is more interesting and suggestive than the development in man of ethical qualities which prompt leadership for good. Such qualities are possessed in unusual fullness by Mr. Swope and in doing him honor, we honor ourselves.

"The drastic income tax law of 1917, which I was required to administer, brought the Federal Government and industry into partnership. Concluding that both partners should jointly study their mutual problems, I organized an advisory group of business men to co-operate in interpreting and applying the new and complex law. The plan worked so satisfactorily that when I became Secretary of Commerce in 1933, I began a search for outstanding industrialists to serve as a Business Advisory Council for the Department of Commerce. We were very fortunate in securing Gerard Swope as the first chairman of that Council. Under his guiding

hand, there was organized an able and eminent group of business men who, without compensation and at great personal sacrifice, co-operated with the Department of Commerce, the other executive units of the Government and with the Congress, in studying the problems of the depression period, and, later, the grave problems of the defense program of the Government. Assisted by these advanced studies, several of these men are now prominently identified with the war program and are rendering invaluable service to their Government. I cherish with deep gratitude the very valuable guidance given by Gerard Swope as first chairman of the Business Advisory Council of the Department of Commerce."

The following is a letter received from Fiorello La Guardia, mayor of New York City:

"Mr. Gerard Swope's public spirit and willingness to serve the public was well demonstrated when on the day of his retirement, to which he had looked forward for a long time for a much needed rest, I asked him to step in and take the chairmanship of the New York City Housing Authority. I had a problem on my hands. There were millions of dollars in construction or about to commence. There were thousands of families waiting the completion of these low-cost housing units. In typical Gerard Swope fashion he curtailed a planned trip to South America, worked on the ship, came back in a few weeks and assumed his duties. He did a creditable job, a difficult one, and served up to the time that he was called to Washington. The city is in debt to Gerard Swope for his splendid services and is indeed grateful."

Finally, comes a letter from Gerard Swope's closest associate, Owen D. Young, whom I asked for help. Because his reply is so interesting and because he is such a master of the subject under discussion, I am going to take the liberty of quoting his entire letter:

"Replying to your letter of November 30 about Gerard Swope, I should say first of all that I am primarily interested in the over-all picture of a man and secondarily in his accomplishments. The latter are only items of proof, the detail of the picture.

"Starting with his most obvious characteristic, one recognizable on the instant of a first meeting, is his dynamic personality. He is like a spring under tension always, never spent and never relaxed. The next characteristic is his utter incapacity for ambiguity. He can not think ambiguously, and he could not speak ambiguously if he would. As a result of these two qualities, you have force and clearness which are as vital to an effective person as they are to effective speech. Together they are an instrument of penetration like the scalpel or the X-ray, a tool which nature gave him and which has improved progressively with use. It is a dangerous tool which has ruined many men. It is safe only when coupled to industry and anchored to character.

"Gerard Swope is passionately industrious and inescapably devoted to principle. His industry urges him to know more about any subject he touches than others, at least more of the vitals of it. His principle is always an insurance against industry leading him astray.

"What I have said above is true whether he touches engineering or accounting or finance or salesmanship or negotiation in any form. It was true of him as an officer of the Western Electric Company. It was true of his service in the last war under General Goethals and his conspicuous capacity to adapt himself as a civilian to a military regime. It was true of him as president of the International General Electric Company which stretched his geography and his experience with other peoples and other races. He was successful alike with the English, French, Germans, Japanese, and Chinese, to mention only the conspicuous samples. I dare say that it has been true of him as a trustee of your own Institute [Massachusetts Institute of Technology].

"These are the reasons why Gerard has been such a great success as president of the General Electric Company: the determination to understand its sprawling activities, the capacity to relate engineering, manufacture and sales into a single integrated picture, yet with full comprehension of the variables in each of the individual pieces. This means great capacity to deal with things. It would all be useless, however, unless it were intimately geared to a knowledge and understanding of people.

"That is the reason why Gerard did run a great concern without a strike. That is the reason why he was General Electric's most successful salesman. That is the reason why programs of retirement, pensions, savings, unemployment protection, and similar contributions to the welfare of his associates in the General Electric Company, which included every employee, were adopted and made practically effective to the utmost extent that competitive conditions and corporate solvency would permit.

"The problem of making a great concern function for the maximum benefit of employees, stockholders, and the public requires not only the conscience of a trustee, but that clarity of mind and fairness and firmness of decision which prevents any one of the three encroaching on the others. They are all superficially in conflict and all basically unified in ultimate interest. One must have keen human sympathy to do such a job. He must keep his emotions controlled by his intelligence and keep all of them in hand by devotion to principle. That means intelligence, human sympathy, and character functioning at their best.

"Such are the qualities which, to my mind, have made Gerard Swope worthy of the Hoover Medal."

Honored already by medals and decorations at home and abroad and by numerous honorary degrees—such is the man, and the record of the man, to whom the Hoover Medal has been awarded.

The Engineer and Social Development

GERARD SWOPE, Fellow AIEE

THE citation given me is much more generous than my efforts warrant—it is really the reflection of the ideal of the work of engineers for the public good. It is recognized that engineers are dealing not only with material and natural forces but with and for human beings.

This ideal of the engineering societies points the way to a wider opportunity for the engineers to take a greater part in the progress of social development. The foundation of such participation should be a broader and more comprehensive conception of the education of the engineer. Today, we have abandoned the old fatalistic idea that engineers are born and not made, and we now believe that much can be done by training and environment in broadening the scope of the engineer's activities.

The foundation of engineering training is, of course, in the exact sciences, mathematics, physics, and chemistry. The education of the engineer, however, must not be confined to these basic subjects but should include

history of the development of man, his industries, and his relations with other men, as well as the migration and development of peoples, thus leading to a broader and more tolerant understanding of differences among people. A knowledge of the growth of industry and especially the struggle of labor for a larger share of the fruits of production and a recognition of labor's place in industry, should assist the engineer in taking his rightful place in society and aid him in developing policies that will ensure greater good, both materially and spiritually for the greater number.

My efforts some years ago along this line of expanding the engineering curriculum met with great difficulty. Because of the many subjects that had to be given time and study, it seemed the only solution was to lengthen the course of training. Engineering is no longer an extension of a course in manual training or a study of purely technical subjects; it is a broad profession. Not so long ago, neither law nor medicine required a general training in academic or scientific subjects, but now a college course and degree is required before undertaking professional work in these fields. As in law and in medicine, the engineer deals with human beings and therefore should have a broad basis of education before undertaking his professional work. The real danger for the engineer is that the fine qualities of the field in which he is working, the exactness of the laws of nature, and the accuracy with which he must determine his design, may easily lead to narrowness of outlook and rigidity in his dealing with men. The tendency of engineers in dealing with human beings is to assume that two and two must always make four. He must be open-minded and liberal in making allowances that possibly in one case two and two may make only three and seven eighths and that in another case two and two may make four and one eighth. The engineer's problem in machine design is to secure stability of structure, efficiency, and reliability in operation. The smooth motion and decreased loss from friction that is highly desirable in machines should also be sought after in human relations.

It may seem strange, in the midst of war, when everything is being done to shorten the period of training, to get men into action, that one should advocate lengthening the course of engineering education. However, I am not speaking for today, nor is the ideal of the engineering societies for today. There is no doubt we shall

eventually have victory and peace, and the engineers must be ready then for a larger role in society than ever before.

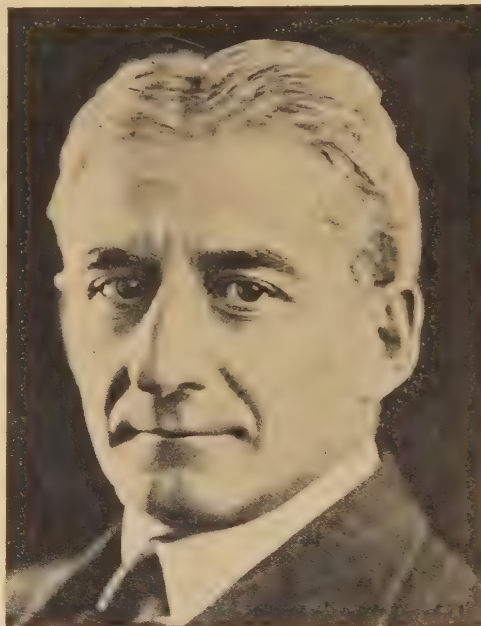
The English, in their universities, through their emphasis on the "honours" courses, have been successful in the development of the exceptional student. I remember very well a talk I had many years ago with Lord Rutherford,

then Sir Ernest, the head of the Cavendish Laboratories of Cambridge University, and himself an outstanding scientist and a winner of the Nobel Prize. We were discussing engineering education in England and the United States. He said, "I grant that the average of your engineering graduates is higher than ours, but you can't touch our honour men. We don't pay much attention to the average man—he may get something from the atmosphere—but we devote ourselves to the top quarter of the class." I came back filled with the idea that if we could keep the average of our engineering graduates as high as it had been and still give more time and opportunity to the exceptional student, we would make a real contribution to engineering education and even-

tually to society, by engineering leadership. To that end, graduate fellowships were offered to those who graduated first and second in the "honors" course and wished to continue their studies. Only a feeble beginning has been made in this country along this line and much more could be done in establishing a broader foundation and in developing the exceptional man.

Engineers have achieved much in the great record that America is making in war production. They will be much needed to rebuild the world not only in a material sense but humanly, which heretofore has been considered outside the engineer's field. Society has a right to look to engineers, with their training in accuracy and truth, for leadership in industry, where their services are especially needed to develop assurance of employment, to further progress in simpler design and better methods of manufacturing, the attainment of lower costs, resulting in lower prices to the community, and a wider distribution of the products of industry.

There is so much constructive work to be done to make our communities better places in which to live, to give assurance of work and leisure, without fear, in which to enjoy the benefits of better living, that the ideal of the engineering societies should constantly be before us not only for a political but also for an economic and industrial democracy.



Gerard Swope, 1942 Hoover Medalist

Ultrashort Electromagnetic Waves

II—Transmission Lines at Ultrahigh Frequencies

JOHN R. RAGAZZINI
ASSOCIATE AIEE

This article is the second in a series of six on ultrashort electromagnetic waves, all presented originally before the basic science group of the AIEE New York Section as a symposium of six lectures surveying ultrahigh-frequency theory. The first article, "Electromagnetic Theory," by Doctor Ernst Weber, appeared in the March issue. This second article presents simplifications and approximations of the usual engineering solutions for the transmission line that are valid only for very high frequencies. The resulting expressions are of great practical advantage in designing transmission-line circuit elements.

PAUL C. CROMWELL, Chairman, Symposium Committee
(College of Engineering, New York University, New York, N. Y.)

THE conventional transmission line is, in the general sense, a guide for the propagation of electromagnetic energy from one point to another.^{1-5,7} The more modern methods of dealing with a problem of this type involve a study of the field between the conducting surfaces making up the guide rather than the currents and voltages induced in these surfaces. The conventional line, however, implies the assumption that the field patterns are known and correspond to the patterns obtained under static conditions. For instance, in Figure 1, the assumed field patterns for a two-wire line and a coaxial cable are sketched.

These field patterns are based on the assumptions that they are produced by a static distribution of charge on the surfaces of the conductors and the currents flowing in these conductors. Using standard methods, the effects of the electric and magnetic field can be related to parameters commonly associated with circuits. For instance, by integrating the total flux linkages per unit length produced in the conductors per ampere of current in the conductor, the self-inductance per unit length of line can be determined. In addition, by integrating the electric field intensity from the surface of one conductor to the surface of the other, a relation between the voltage between conductors and charge per unit

length can be found. The ratio of charge per volt yields the capacitance per unit length. In this way, it is possible to relate the field concepts of E and H to the circuit concepts of L and C per unit length.

The values of inductance and capacitance per unit length which result from such an integration are:

(a) For a two-wire line of circular cross section conductors:

$$L = (4)(10^{-7}) \log_e \frac{D}{a} \text{ henrys per loop meter} \quad (1)$$

$$C = \frac{1}{(36)(10^9) \log_e \frac{D}{a}} \text{ farads per loop meter} \quad (2)$$

where D is the separation between lines measured from center to center and a is the radius of the wire. The term loop meter implies the assumption that the inductance is calculated for both lines.

(b) For a coaxial line of circular cross section

$$L = (Q)(10^{-7}) \log_e \frac{b}{a} \text{ henrys per loop meter} \quad (3)$$

$$C = \frac{1}{(18)(10^9) \log_e \frac{b}{a}} \text{ farads per loop meter} \quad (4)$$

where b is the inside radius of the outer conductor and a is the outside radius of the inner conductor. The inductance formulas neglect the effects of the magnetic field inside the metal making up the conductors and the capacitance formulas neglect the proximity effects which distort the charge distributions on the surfaces of the conductors. In the case of ultrahigh-frequency propagation, however, the penetration of the magnetic field inside the conductor is quite small, and the error caused by this effect is small. Furthermore, in the case of a two-wire line, the proximity effect on the electric field is important only when the separation between wires is comparable to the diameter of the wire. In the case of coaxial cable, this latter effect is nonexistent because of the symmetrical distribution of charge.

In addition to the effects of the fields on the characteristics of the transmission line, there are the dissipative effects of the conductors and insulators which should be considered. The power losses which are produced

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include the ohmic losses, which are the result of the current's passing through the conductors, and the dielectric losses produced by the oscillatory electric field in the medium used for insulation between the conductors. In ultrahigh-frequency applications, the dielectric losses are frequently neglected and the ohmic losses are assumed to be quite small. At ultrahigh frequencies the ohmic losses are produced by currents flowing only on the surfaces of the metallic conductors so that standard depth-of-penetration formulas can be used for their determination. The depth of penetration is given by the relation:

$$\delta = \frac{503.3 \sqrt{\rho}}{\sqrt{f \frac{\mu}{\mu_0}}} \text{ meters} \quad (5)$$

$$\delta = \frac{0.0664}{\sqrt{f}} \text{ meters for copper} \quad (6)$$

where ρ is the resistivity in ohm-meters (1.724×10^{-8} for copper), μ/μ_0 is the relative permeability (1.0 for copper) and f is the frequency in cycles per second.

The resistance per meter of length for standard conductors of circular cross section, the radius of which is a , therefore becomes:

$$R = \frac{\rho}{2\pi a \delta} = \frac{(1.724)(10^{-8})\sqrt{f}}{(2\pi a)(0.0664)} \quad (7)$$

$$= (4.16)(10^{-8}) \frac{\sqrt{f}}{a} \text{ ohms/meter} \quad (8)$$

where a is the radius of the wire in meters. The rela-

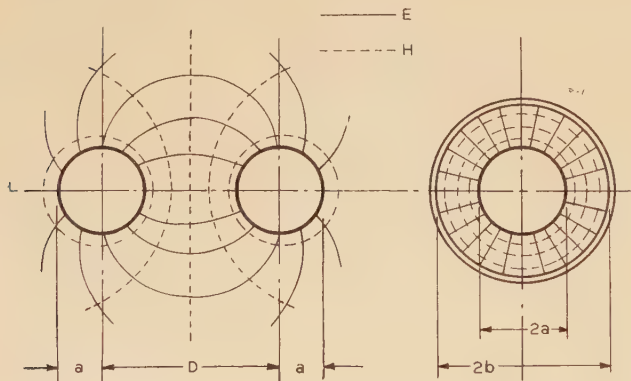


Figure 1. Field patterns for two-wire and coaxial transmission lines

tion gives the resistance for a meter of length of a single conductor regardless of whether the current is carried on the outside of a solid copper conductor or the inside of a hollow cylindrical conductor. In the latter case, the radius of the wire refers to the inside radius of the hollow tube.

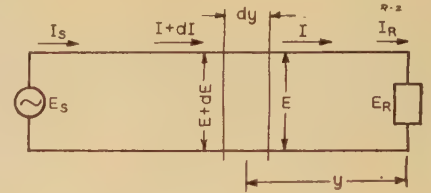
In addition to these losses, there are the dielectric

losses which can be minimized by the use of high-quality low-loss materials. In most cases these losses are negligible in relation to the ohmic losses. At any rate, they shall be neglected in the discussions which follow.

FUNDAMENTAL RELATIONS^{1-4,7,11}

The relations between voltage and current on a transmission line may be determined in terms of the line parameters, L , C , R , and G , by solving the differen-

Figure 2. The long transmission line



tial equations of the line. The assumption can be made that the current and voltage are sinusoidal with respect to time and may be represented by vector expressions. Considering, then, an infinitesimal section of line as shown in Figure 2, the relation for voltage at a distance of y meters from the receiving end is given by:

$$\frac{dE}{dy} = I(R + j\omega L) = IZ \quad (9)$$

where R and L are the resistance and inductance of the line per loop meter respectively. Similarly, the current relation is given by:

$$\frac{dI}{dy} = E(G + j\omega C) = EY \quad (10)$$

where G and C are the effective conductance and capacitance between lines per loop meter. By differentiating equation 9 with respect to y and substituting equation 10 in the resulting expression, the following relation results:

$$\frac{d^2E}{dy^2} = Z \frac{dI}{dy} = (ZY)E \quad (11)$$

Similarly,

$$\frac{d^2I}{dy^2} = Y \frac{dE}{dy} = (ZY)I \quad (12)$$

These equations yield exponential solutions which can be combined into the conventional hyperbolic solutions in which the boundary conditions that:

$$\left. \begin{matrix} E = E_R \\ I = I_R \end{matrix} \right\} \text{ at } y=0 \quad \left. \begin{matrix} E = E_s \\ I = I_s \end{matrix} \right\} \text{ at } y=l \quad (13)$$

where E_s and I_s are the sending-end voltage and current and E_R and I_R are the receiving-end voltage and current respectively, and l is the length of the line. The final relations are shown in equation 14.

$$\left. \begin{aligned} E_y &= E_R \cosh \gamma y + I_R Z_0 \sinh \gamma y \\ I_y &= I_R \cosh \gamma y + \frac{E_R}{Z_0} \sinh \gamma y \end{aligned} \right\} \quad (14)$$

in which E_y and I_y are the voltage and current at a point y meters from the load. Also:

$$\left. \begin{aligned} E_s &= E_R \cosh \theta + I_R Z_0 \sinh \theta \\ I_s &= I_R \cosh \theta + \frac{E_R}{Z_0} \sinh \theta \end{aligned} \right\} \quad (15)$$

where

$$\theta = \gamma l; \quad \gamma = \sqrt{Z_1 Y}; \quad Z_0 = \sqrt{\frac{Z_1}{Y}}$$

The constant γ is called the propagation constant of the line, θ is the line angle and is given in hyperbolic radians, and Z_0 is the characteristic impedance of the line in ohms. Generally:

$$\gamma = \alpha + j\beta \quad (16)$$

where α is called the attenuation constant and β is the wave-length constant and is indicative of the phase shifts which are introduced by the line. An important special case of the current and voltage distributions is that in which the receiving load impedance, Z_R , is exactly equal to the characteristic impedance of the line, in which case the line is said to be matched. Making this substitution in equation 14 and simplifying,

$$\left. \begin{aligned} E_y &= E_R e^{\gamma y} = (E_R e^{\alpha y}) e^{j\beta y} \\ I_y &= I_R e^{\gamma y} = (I_R e^{\alpha y}) e^{j\beta y} \end{aligned} \right\} \quad (17)$$

Thus, in a matched line, the current and voltage vary exponentially in magnitude along the line with a phase shift which is proportional to the distance traveled along the line. This special case is one of the most important in ultrahigh-frequency power transmission, and will be considered more in detail later.

Several important approximations can be made in the equations, if it is assumed that R is very small and that G is completely negligible. For instance, the characteristic impedance of the line, Z_0 , can be written as follows:

$$Z_0 = \sqrt{\frac{R + j\omega L}{j\omega C}} = \sqrt{\frac{L}{C} + \frac{R}{j\omega C}} \quad (18)$$

This expression can be expanded by means of the binomial theorem into the form (by neglecting the higher order terms):

$$Z_0 = \sqrt{\frac{L}{C}} - \frac{jR}{2\omega\sqrt{LC}} \quad (19)$$

If the resistance of the line also is negligible, the characteristic impedance of the line is a pure resistance and can be expressed by $\sqrt{L/C}$, the value of which is given by the formula:

$$Z_0 = 276 \log_{10} \frac{D}{a} \quad (20)$$

for a two-wire line where D is the separation between centers of the conductors and a is the outside radius of the conductors. For a coaxial line, the formula becomes:

$$Z_0 = 138 \log_{10} \frac{b}{a} \quad (21)$$

where b is the inside radius of the outside conductor and a is the outside radius of the inside conductor. These formulas neglect the effects of the magnetic field inside the metal of the conductors and the distortions in charge distributions on the conductors caused by proximity effects. The latter effect is not present in coaxial conductors because of the symmetry of the electric field. In the case of a two-wire line, for instance, the error introduced by neglecting these effects is 5.5 per cent when the ratio D/a is 4.0, becoming progressively less as the separation between conductors becomes larger.

By applying the same approximations which led to the formulas in equations 18 and 19, the propagation constant can be expressed as follows:

$$\gamma = \sqrt{(R + j\omega L)(j\omega C)} = j\omega\sqrt{LC} \left(1 - \frac{jR}{\omega L}\right)^{1/2} \quad (22)$$

which can be expanded by means of the binomial theorem to:

$$\gamma = \frac{R}{2} \sqrt{\frac{C}{L}} + j\omega\sqrt{LC} \quad (23)$$

The quantity \sqrt{LC} has the dimensions of the inverse of velocity. As a matter of fact, if the penetration of the magnetic field into the conductors is negligible and the dielectric permittivity of the insulation between conductors is unity, this velocity is that of light in free space. In view of this relationship and noting the fact that $\sqrt{L/C}$ is virtually the characteristic impedance if the line resistance and conductance can be neglected, the propagation constant can be expressed:

$$\gamma = \frac{R}{2Z_0} + j\frac{\omega}{v} \quad (24)$$

where v is the velocity of propagation of the line. Since v/f is recognized as the wave length of the propagation, or more specifically as applied to the line, it is the distance over which a phase shift of 2π radians occurs, the propagation constant can be written:

$$\gamma = \frac{R}{2Z_0} + j\frac{2\pi}{\lambda} \quad (25)$$

where λ is the wave length of the propagation and is equal to the wave length in free space if the line velocity is that of free space. It must be recognized that there are many approximations in the derivations of these constants but that they are accurate enough for use with most ultrahigh-frequency lines.

One extremely important approximation is that which can be applied to equation 14 when the resistance R

and the conductance G are completely negligible. Under these circumstances, the equations for voltage and current along the line may be written as:

$$\left. \begin{aligned} E_y &= E_R \cos \beta y + j I_R Z_0 \sin \beta y \\ I_y &= I_R \cos \beta y + j \frac{E_R}{Z_0} \sin \beta y \end{aligned} \right\} \quad (26)$$

since $\cosh j\beta y = \cos \beta y$ and $\sinh j\beta y = j \sin \beta y$. By

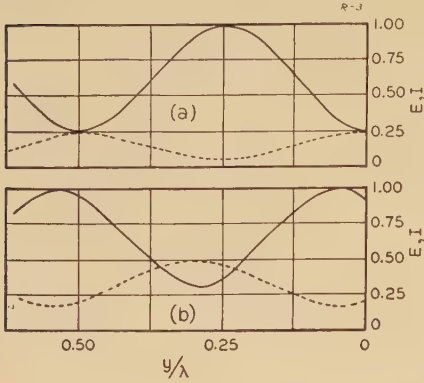


Figure 3. Voltage and current variations along line for

- (a) $Z_R = 0.25 Z_0$
(b) $2Z_0 \angle 45$

means of these relations, it is possible to obtain relatively simple expressions for the current and voltage distributions along the line when a load is applied to the end of the line. If the load impedance is given by the vector quantity Z_R , then the current on the receiving end, I_R , is given by E_R/Z_R , making it possible to write the voltage equation 26 as:

$$E_y = E_R \cos \beta y + j \frac{E_R}{Z_R} Z_0 \sin \beta y \quad (27)$$

It is observed that this equation can be rearranged as follows:

$$E_y = \frac{E_R (Z_R + Z_0)}{Z_R} \left[\left(1 + \frac{Z_R - Z_0}{Z_R + Z_0} \right) \cos \beta y + j \left(1 - \frac{Z_R - Z_0}{Z_R + Z_0} \right) \sin \beta y \right] \quad (28)$$

The quantity $\frac{Z_R - Z_0}{Z_R + Z_0}$ is a term which appears in transmission-line equations very frequently and is called the voltage reflection factor $N \angle \phi$. This factor is not necessarily a scalar quantity but has associated with it an angle ϕ contributed by the load impedance Z_R since the characteristic impedance of the line Z_0 is a pure resistance for the case where the resistance and conductance of the line are negligible. Rewriting equation 28:

$$E_y = \frac{E_R (Z_R + Z_0)}{Z_R} [(1 + N \angle \phi) \cos \beta y + j(1 - N \angle \phi) \sin \beta y] \quad (29)$$

Combining terms containing the voltage reflection factor:

$$E_y = \frac{E_R (Z_R + Z_0)}{Z_R} [(\cos \beta y + j \sin \beta y) + N \angle \phi (\cos \beta y - j \sin \beta y)] \quad (30)$$

Expressing in terms of exponentials:

$$E_y = \frac{E_R (Z_R + Z_0)}{Z_R} e^{j\beta y} [1 + N e^{j(\phi - 2\beta y)}] \quad (31)$$

The magnitude of the voltage along the line as a function of y , the distance from the load toward the transmitter can therefore be expressed as:

$$|E_y| = \left| \frac{E_R}{Z_R} \right| \left| \frac{Z_R + Z_0}{2} \right| \sqrt{1 + N^2 + 2N \cos(\phi - 2\beta y)} \quad (32)$$

In a similar manner, the current along the line is given by:

$$I_y = \frac{I_R (Z_R + Z_0)}{Z_0} e^{j\beta y} [1 - N e^{j(\phi - 2\beta y)}] \quad (33)$$

and its magnitude:

$$|I_y| = \left| \frac{I_R}{Z_0} \right| \left| \frac{Z_R + Z_0}{2} \right| \sqrt{1 + N^2 - 2N \cos(\phi - 2\beta y)} \quad (34)$$

A plot of the current variation along a line for the case where the load impedance is twice the characteristic impedance at an angle of 45 degrees and for a load of one-fourth the characteristic impedance at a zero angle is shown in Figure 3. A special case is that in which the load impedance is exactly equal to the characteristic impedance. In that case, the reflection factor is zero, and the magnitude of the current and voltage along the line is uniform. The line is said to be "flat" under such conditions and represents a desirable mode of operation when the efficiency is to be maintained high.

TRANSMISSION OF POWER^{2,3,11}

One of the primary functions of the transmission line is for the transfer of ultrahigh-frequency power from one point to another. This transmission should be accomplished with minimum losses or maximum efficiency. As an indication of how this is accomplished, the losses over a wave length (2π radians of phase shift) should be calculated. It is assumed that the line resistance, R , is low enough to permit the use of equation 34 which was derived on the basis of no losses whatsoever to represent the current magnitude along the line. If the loss is desired per unit length of line, a mean-square value of current averaged over a typical cycle of variation can be integrated and multiplied by the resistance of the line per unit length. This method will be used with the following results:

$$\begin{aligned} \text{Average copper loss} &= \frac{I_y^2 R}{2} = \frac{R |I_R|^2}{2} \left| \frac{Z_R + Z_0}{2} \right|^2 \frac{1}{2\pi} \times \\ &\quad \int_0^{2\pi} (1 + N^2 - 2N \cos \psi) d\psi \\ &= \frac{1}{2} \left| \frac{I_R}{Z_0} \right|^2 \left| \frac{Z_R + Z_0}{2} \right|^2 (1 + N^2) R \text{ watts/loop meter} \end{aligned} \quad (35)$$

This can be simplified further to:

$$\text{Average copper loss} = \frac{I_R^2 (Z_R^2 + Z_0^2) R}{4 Z_0^2} \quad (36)$$

If the load Z_R is a resistance, the power output of the line is given by the simple expression $\frac{I_R^2 Z_R}{2}$ and the loss factor of the line can be defined as:

$$\frac{\text{Loss}}{\text{Output}} = \frac{R}{2Z_R} \left(\frac{Z_R^2 + Z_0^2}{Z_0^2} \right) \quad (37)$$

whose minimum value is reached when $Z_R = Z_0$. In other words, the maximum efficiency is reached when the line is matched, and under practical operating conditions, this condition is approached reasonably well.

When the line is matched, the current and voltage are given by equations 17, and the line attenuation for a two-wire line is therefore:

$$\alpha = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{R}{2Z_0} = \frac{(1.5)(10^{-10})\sqrt{f}}{a \log_{10} D/a} \text{ nepers/meter} \quad (38)$$

where R is taken from equation 8 but the value is doubled since loop-meter values must be used to account for the outgoing and return conductors. Expressing the result in decibels, the line attenuation for a matched two-wire line is:

$$db = \frac{(1.3)(10^{-9})\sqrt{f}}{a \log_{10} D/a} db/\text{meter} \quad (39)$$

For the coaxial line, the attenuation under matched conditions is given by:

$$\alpha = \frac{(1.5)(10^{-10})\sqrt{f}}{\log_{10} b/a} \left[\frac{1}{a} + \frac{1}{b} \right] \text{ nepers/meter} \quad (40)$$

In terms of decibels per meter, the attenuation factor is:

$$db = \frac{(1.3)(10^{-9})\sqrt{f}}{\log_{10} b/a} \left[\frac{1}{a} + \frac{1}{b} \right] db/\text{meter} \quad (41)$$

For a given value of outside conductor, b , this attenuation factor is a minimum when the ratio of b/a is approximately 3.5.

It is evident that in order to obtain the minimum attenuation given by equations 39 and 41, the line must be matched. In other words, the line must be loaded effectively by a resistance the value of which is equal to the characteristic impedance of the line. Since many loads, such as antennas, are not necessarily of the correct value, nor are they nonreactive, some means of transforming the load to the proper value must be provided. This is accomplished by the use of reactive line elements known as "stub lines" or "quarter-wave transformers," and the details of their adjustment will be given later.

REACTIVE LINE ELEMENTS

A transmission line section may be used as a reactive element by either short-circuiting or open-circuiting the receiving end of the line. The input impedance of a short-circuited line may be determined by setting E_R at zero in equations 15.

$$Z_s = \frac{E_s}{I_s} = \frac{I_R Z_0 \sinh \theta}{I_R \cosh \theta} = Z_0 \tanh (\alpha + j\beta)l \quad (42)$$

If it is assumed that the attenuation is sufficiently small so that $\sinh \alpha l = \alpha l$ and $\cosh \alpha l = 1.0$, then the input impedance can be written as:

$$Z_s = Z_0 \left[\frac{\alpha l + j(1 - \alpha^2 l^2) \sin \beta l \cos \beta l}{\alpha^2 l^2 + (1 - \alpha^2 l^2) \cos^2 \beta l} \right] \quad (43)$$

This input impedance is inductive for lengths, l , between zero and $\lambda/4$, while it is capacitive for lengths between $\lambda/4$ and $\lambda/2$. A special case of this input impedance is that in which the line length is $\lambda/4$ making $\beta l = \pi/2$:

$$Z_s = \frac{2Z_0^2}{Rl} = \frac{8Z_0^2}{R\lambda_0} \quad (44)$$

where R is the resistance per loop meter, l is the length of the line in meters, and Z_0 is the characteristic impedance. The input impedance reaches a maximum value at this length and the input impedance is virtually nonreactive. It is not exactly so because of the slight phase angle contained in the characteristic impedance Z_0 .

A measure of the effectiveness of a short-circuited line section as a reactive element is the Q of the element defined as:*

$$Q = \frac{X_L}{R} \quad (45)$$

for lengths considerably less than $\lambda/4$. Then using 43 by taking the ratio between the reactive component and the resistive component,

$$Q = \frac{(1 - \alpha^2 l^2) \sin \beta l \cos \beta l}{\alpha l} \quad (46)$$

A useful approximation which can be applied in estimating the lengths of short-circuited line sections is that in which the attenuation factor is negligible. Then:

$$Z_s = jZ_0 \tan \beta l \quad (47)$$

Similar relationships can be derived for an open line section using equations 26 this time setting I_R at zero. The relations are:

$$Z_s = \frac{E_s}{I_s} = Z_0 \coth (\alpha + j\beta)l \quad (48)$$

$$Z_s = Z_0 \left[\frac{\alpha l - j(1 - \alpha^2 l^2) \sin \beta l \cos \beta l}{\alpha^2 l^2 + (1 - \alpha^2 l^2) \sin^2 \beta l} \right] \quad (49)$$

$$Q = \frac{(1 - \alpha^2 l^2) \sin \beta l \cos \beta l}{\alpha l} \quad (50)$$

and if the attenuation is negligible,

$$Z_s = -jZ_0 \cot \beta l \quad (51)$$

The input impedance of an open-circuited line is capacitive if the length of the line section is less than $\lambda/4$ and inductive if the line length is between $\lambda/4$ and $\lambda/2$. If the length is just $\lambda/4$, the impedance becomes

* This definition is limited in scope and is applicable only to lines considerably shorter than one-quarter wave length. The basic definition for the Q of a circuit is the ratio of the maximum energy storage in the system divided by the loss per cycle. In the case of short lines, however, the energy storage is mostly magnetic and the definition given in equation 45 is approximately correct.

nonreactive and reaches a minimum value given by:

$$\tilde{Z}_s = \frac{Rl}{2} \quad (52)$$

The transmission line can, therefore, be used to obtain inductive or capacitive components at ultrahigh frequencies with values of Q not otherwise realizable. These short line sections are known as "stub lines" and can be used as filter elements, and as reactances for use in line matching to be described later.

RESONANT CIRCUIT ELEMENTS^{5-7,10}

Transmission-line sections find a very important use in applications where high- Q resonant circuit elements at high frequencies are required. For instance, a short-circuited line element has the characteristics of a resonant circuit when line lengths reach $\lambda/4$ or odd multiples thereof. A plot of the reactance variations of a short-circuited dissipationless transmission line as

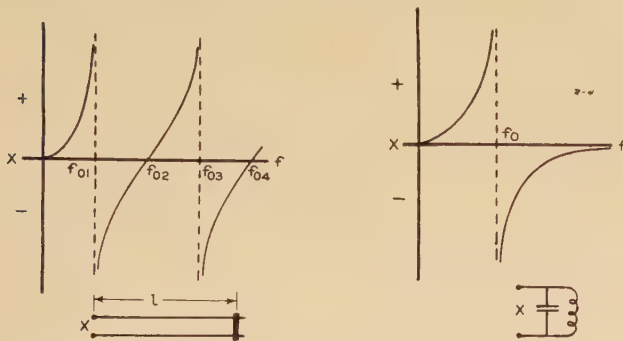


Figure 4. Input reactance of short-circuited line and tuned circuit

given by equation 47 is given in Figure 4. In the same figure are given the reactance variations of a parallel tuned circuit. It is observed that at certain frequencies f_{01} , f_{03} , and so forth, the impedance rises to infinity while the circuit becomes inductive at the frequencies slightly below these values and capacitive at the frequencies above these frequencies. These variations are exactly similar to those of a parallel tuned circuit, thus making it possible for a short-circuited line to replace it in these frequencies. The infinite impedances are reached for line lengths such that:

$$\beta l = \frac{(2n+1)\pi}{2} \quad (53)$$

or

$$l = \frac{(2n+1)\lambda}{4} \quad (54)$$

where n is an integer. Similarly, for line lengths which are multiples of $\lambda/2$, the input impedance of a short-circuited line varies in the same way as a series resonant circuit.

A practical line has losses however, which make the

input impedance finite at resonance as given by equation 44. The lower the line losses, the higher is the input impedance which can be developed across the input terminals of the line. An important factor which should be investigated is the variation of the magnitude of the input impedance as the frequency is varied slightly so that an estimate of the Q of the tuned circuit can be made. Using equation 42 this variation may be evaluated,

$$\tilde{Z}_s = \tilde{Z}_0 \frac{\sinh(\alpha l + j\beta l)}{\cosh(\alpha l + j\beta l)} \quad (55)$$

At resonance, the angle βl is $\pi/2$, but for slight frequency deviations of $\Delta\omega$, the angle βl becomes $\left(\pi/2 \pm \frac{\Delta\omega}{v} l\right)$ where v is the velocity of propagation on the line and l is the length of the line. Thus the input impedance, \tilde{Z}_s , for values near resonance can be expressed by:

$$\tilde{Z}_s = \tilde{Z}_0 \frac{\sinh\left[\left(\alpha l + j\pi/2\right) + j\frac{\Delta\omega}{v} l\right]}{\cosh\left[\left(\alpha l + j\pi/2\right) + j\frac{\Delta\omega}{v} l\right]} \quad (56)$$

Expanding and simplifying, the following form may be obtained:

$$\tilde{Z}_s = \frac{\tilde{Z}_0}{\tanh\left(\alpha l + j\frac{\Delta\omega}{v} l\right)} \quad (57)$$

If the magnitude of both the attenuation factor, α , and the frequency deviation, $\Delta\omega$, is small, then the $\tanh\left(\alpha l + j\frac{\Delta\omega}{v} l\right)$ is virtually the same as $\left(\alpha l + j\frac{\Delta\omega}{v} l\right)$.

Hence:

$$\tilde{Z}_s = \frac{\tilde{Z}_0/\alpha l}{1 + j\frac{\Delta\omega}{\alpha v}} \quad (58)$$

The Q of the resonant circuit can be defined as the ratio of the resonant frequency and twice the frequency variation required to reduce the impedance to 0.707 times the resonant value. This condition is reached when:

$$\frac{\Delta\omega}{\alpha v} = 1 \quad (59)$$

Hence,

$$Q = \frac{\omega_0}{2\Delta\omega} = \frac{\pi f_0}{\alpha v} = \frac{2\pi\tilde{Z}_0}{R\lambda_0} \quad (60)$$

where R is the resistance per loop meter of line, \tilde{Z}_0 the characteristic impedance of the line and λ_0 is the wave length of the propagation measured at line velocity.

An open line has characteristics similar to those of the short-circuited line, except for an interchange of the series and parallel resonant points. The input impedance of an open line is given by equation 48.

$$\tilde{Z}_s = \tilde{Z}_0 \coth (\alpha l + j \beta l) \quad (61)$$

Near the first resonant point, when $\beta l = \pi/2$, the input impedance is

$$\tilde{Z}_s = \tilde{Z}_0 \alpha l \left(1 + j \frac{\Delta \omega}{\alpha v} \right) \quad (62)$$

The Q of a resonant open line is given by exactly the same formula as that for the short-circuited line, equation 60.

The resonant line can be used as a tank circuit for oscillators, amplifiers, or measuring devices with values of Q and input impedance not realizable by other methods. Since the frequency stability of oscillators depends to a large extent on the Q of the resonant circuits, line sections are particularly adapted to ultrahigh-frequency applications.

THE LINE AS A MEASURING DEVICE

One of the uses of the transmission line is in the measurement of various quantities such as frequency and impedance at ultrahigh frequencies. One of the most familiar of these applications is the use of Lecher wires for the measurement of frequency. For instance, if a short-circuited transmission line is coupled to a source of ultrahigh-frequency power the frequency of which is to be measured, the line becomes resonant when its effective length is an integral number of half wave lengths. At the resonant condition, the currents in the line become large and the power absorption from the oscillator increased. If the short circuit is moved down the line, a distance equal to a half wave length, as shown in Figure 5, the circuit becomes resonant again and an indication is noted.

This indication is either a grid current dip in the oscillator tube or a measure of the current in the line

itself by some means such as a crystal microammeter or a low-range thermal instrument. The frequency of the oscillator is given by:

$$f = \frac{v}{\lambda} \quad (63)$$

where $v = 1/\sqrt{LC}$, virtually the velocity of light and λ is twice the movement of the short-circuiting stub for consecutive indications. Various refinements have been suggested and used in this measurement, but, fundamentally, they are all based on the principle outlined. It is noted that the measurement of frequency has been converted into a measurement of length.

Another important measurement which can be made with a transmission line is that of impedance at ultrahigh frequencies. Here too, the value of impedance is

determined by converting all measurements into those of length, and relative voltage or current. The unknown impedance is placed at the end of a transmission line as shown in Figure 6. The variation of voltage and current along the line is given by equations 32 and 34. The voltage E or the current I need be measured only in relative terms by means of a coupling loop and thermal milliammeter which measures current in the line or a special quarter-wave voltmeter which is a thermal milliammeter connected to the end of a quarter-wave length line. The data will yield the relative voltages I_{\max} and I_{\min} or E_{\max} and E_{\min} from which can be calculated the magnitude of the reflection factor. Furthermore, the location of either the voltage maximum or the current minimum is used to calculate the phase angle of the load impedance.

The reflection factor, N , is determined by noting that the maximum and minimum values of voltage along the line are given by equation 32

$$\frac{E_{\max}}{E_{\min}} = \frac{I_{\max}}{I_{\min}} = \frac{1+N}{1-N} \quad (64)$$

from which

$$N = \frac{E_{\max}/E_{\min} - 1}{E_{\max}/E_{\min} + 1} \quad (65)$$

The same result is obtained by replacing the voltage maximum and minimum with the current maximum and minimum in equation 65. The phase angle of the reflection factor, ϕ , is obtained by consideration of equation 32 or 34 in which the value of the cosine term becomes unity. For this condition:

$$\phi = 2\beta y_{\max} = \frac{4\pi}{\lambda} y_{\max} \quad (66)$$

where y_{\max} is the distance of the voltage maximum or current minimum as measured from the load end. The magnitude and phase angle of the unknown impedance, \tilde{Z}_x , can be found by solving the following equation vectorially:

$$N \angle \phi = \frac{\tilde{Z}_x - \tilde{Z}_0}{\tilde{Z}_x + \tilde{Z}_0} \quad (67)$$

Charts have been devised which make the solution of this problem graphical rather than analytical, but the basic theory is identical.

In this manner, the measurement of impedance at ultrahigh frequencies is possible by the measurement of

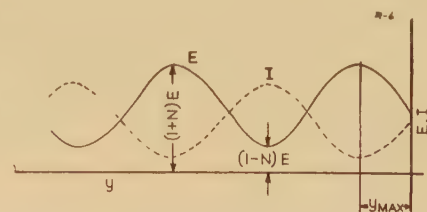


Figure 6. Voltage and current distribution on unmatched line

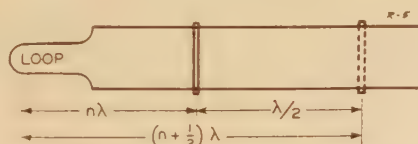


Figure 5. Lecher-wire system

distance and relative current or voltage. The characteristic impedance, Z_0 , which appears in equation 67 is calculated from equation 20 or 21. The impedance which is being measured need not be a dead load such as a resistor, but may be a dynamic load such as an antenna in which the radiation resistance is included in the measurement.

LINE MATCHING AND STUBBING^{1,4}

It has been shown that it is desirable to terminate transmission lines with their characteristic impedance in order to obtain optimum efficiency. In many cases, however, the load which has to be supplied does not have the correct value of impedance to match a line. In this case, some method must be devised to transform the impedance of the load to the proper value. One simple impedance transformer is a quarter-wave-length line section interposed between the line and the load as shown in Figure 7. If the dimensions of the quarter-wave transformer are properly chosen, it is possible to transform the impedance of the load to match the line. In order to do this, it is necessary to know the impedance of the load at the operating frequency, and this must be measured by the method outlined in the preceding section. The characteristic impedance of the line which is to be matched Z_0 must be calculated also. With this information, reference is made to equation 26, and the ratio of input voltage and current taken for the condition that the angle βy is $\pi/2$ radians. This yields the input impedance of the quarter-wave-length line terminated by a load impedance of Z_R :

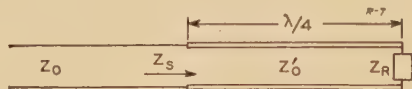


Figure 7. Quarter-wave transformer for nonreactive load

$$Z_s = \frac{I_R(Z_0')^2}{E_R} = \frac{(Z_0')^2}{Z_R} \quad (68)$$

The input impedance given by equation 68 should be made equal to the characteristic impedance of the line, Z_0 . To satisfy this condition, the characteristic impedance of the inserted quarter-wave transformer is obtained by solving equation 68:

$$Z_0' = \sqrt{Z_R Z_0} \quad (69)$$

The matching section should be proportioned to have a characteristic impedance which is the geometric mean between the load impedance and the line impedance.

Another method which is used to transform the impedance of a load to match that of the line is by the use of matching stub lines. In Figure 3 are given plots of voltage and current along the line for two conditions of load. At any point, the ratio of the voltage to the current is the apparent impedance of the line at that

point or conversely, the ratio of current to voltage is the admittance of the line at that point. The admittance varies in value over a considerable range as the point under observation is moved along the line. These variations are shown in Figure 8 in which the conductance and susceptance of the line are plotted separately. At some points, the conductance of the line is $1/Z_0$. This point would give the correct value of impedance to match the line were it not for the fact that there is associated with this conductance a considerable amount of susceptance. The latter can be cancelled out, however, by placing at this point a reactive line element or stub line whose susceptance is equal and opposite to that presented by the line. Thus, so far as the portion of the line ahead of the load is concerned, the apparent impedance of the line in parallel with the stub line is equal to the characteristic impedance. As indicated in Figure 8, the major portion of the line is matched providing the stub is placed close to the load.

To determine the proper location of this stub line, the admittance of the line at any point, y , is calculated by taking the ratio of equations 31 and 33:

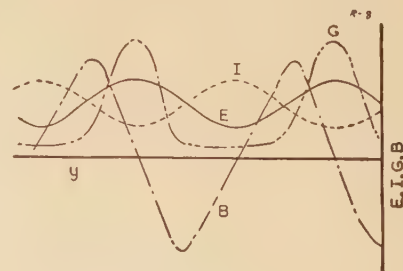
$$Y(y) = \frac{1}{Z_0} \left[\frac{1 - N e^{j(\phi - 2\beta y)}}{1 + N e^{j(\phi - 2\beta y)}} \right] \quad (70)$$

This expression can be simplified into real and imaginary components which represent the conductance and susceptance of the line. After simplification, the real component of the admittance is:

$$G(y) = \text{Re } Y(y) = \frac{1}{Z_0} \frac{1 - N^2}{1 + N^2 + 2N \cos(\phi - 2\beta y)} \quad (71)$$

In order to obtain a matched condition, the input conductance of the line at the point, y , should have a value $1/Z_0$, where Z_0 is the characteristic impedance of the line and which in this discussion is assumed to be non-

Figure 8. Admittance variations on unmatched line



reactive. For a matched condition, then

$$G(y) = \frac{1}{Z_0} \quad (72)$$

which is true when

$$\cos[\phi - 2\beta y + (2n+1)\pi] = -N \quad (73)$$

where n is an integer. Now, from equation 66, the angle of the reflection factor is given by:

$$\phi = 2\beta y_{\max} \quad (74)$$

Substituting this relation in equation 73 and simplifying,

$$\frac{y - y_{\max}}{\lambda} = \frac{\pm \cos^{-1} N}{4\pi} + \frac{2n+1}{4} \quad (75)$$

where y_{\max} is the distance of the voltage maximum measured from the load, and $(y - y_{\max})$ represents the distance measured from the voltage maximum back toward the transmitter. If the reflection factor is expressed in terms of the voltage ratio E_{\max}/E_{\min} , and referring to $(y - y_{\max})$, as Δy the location of the stub line is given by:

$$\frac{\Delta y}{\lambda} = \frac{2n+1}{4} \pm \frac{1}{4\pi} \cos^{-1} \left[\frac{E_{\max}/E_{\min} - 1}{E_{\max}/E_{\min} + 1} \right] \quad (76)$$

The length and type of stub line required at these points is given by the imaginary part of the line admittance as expressed by equation 70. By simplifying the resulting expressions, this input admittance becomes:

$$B(y) = \frac{1}{Z_0} \frac{-2N \sin(\phi - 2\beta y)}{1 + N^2 + 2N \cos(\phi - 2\beta y)} \quad (77)$$

At the points where proper matching of the conductance occurs, the $\cos(\phi - 2\beta y) = -N$, thus making possible the simplification of equation 77 to:

$$B(y) = \frac{1}{Z_0} \left(\frac{\mp 2N}{\sqrt{1 - N^2}} \right) \quad (78)$$

where the signs correspond to those of equation 76. To counterbalance this susceptance, the stub line must present a susceptance which is equal and opposite to the value given by equation 78. Hence,

$$B_{\text{stub}} = \frac{\pm 2N}{Z_0 \sqrt{1 - N^2}} \quad (79)$$

where again the signs correspond to those of equation 76. If the reflection factor is expressed in terms of voltage ratio and inverting, then

$$X_{\text{stub}} = \frac{-1}{B_{\text{stub}}} = \mp Z_0 \frac{\sqrt{E_{\max}/E_{\min}}}{E_{\max}/E_{\min} - 1} \quad (80)$$

While it is possible to calculate the length of the stub line by using equations 47 or 51, it is far simpler to express the results by means of graphical representations. These graphs which are extremely useful in locating and adjusting stubs are given in Figure 9.

Thus, in order to match a line by means of stub lines, it is necessary to measure the relative voltage or current along the line before the stub line is installed. Also necessary is the location of the voltage maximum or the current minimum. From these data, using the curves, it will be possible to match the line within reasonable limits. Generally speaking, it is found that a perfect

match is extremely difficult to obtain, but voltage ratios of about 1.2 can be obtained at the first setting. Improvement of the voltage ratio can be obtained experimentally by slight adjustment of the stub-line length and position.

CONCLUSIONS

Although an exhaustive survey of long transmission lines at ultrahigh frequencies has not been attempted, various important concepts have been developed. The ultrahigh-frequency transmission line can be treated in general as a nondissipative system in which the effects of losses can be approximated later. In the line stubbing and matching relations and line measurement problems, the dissipation of the line has been neglected and, as practical applications have proved, this approximation is justifiable. The use of the line as a circuit element, both reactive and resonant, has been given considerable weight, since this use is unique at ultrahigh frequencies. Further details and other applications will be found in the brief bibliography which has been appended.

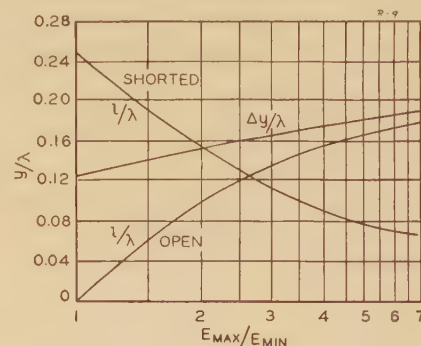


Figure 9. Chart for computing matching stub lengths and locations

Δy is the distance of the stub from the voltage maximum measured toward the source for the short-circuited stub and toward the load for the open stub. l is the length of the stub and λ is the wave length of the wave on the line

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INSTITUTE ACTIVITIES

South West District Technical Meeting to Be Held at Kansas City, Mo., April 28-30

As announced in previous issues, a technical meeting of the AIEE South West District will be held at Kansas City, Mo., April 28-30, 1943. At the same time the annual engineering meeting of the Missouri Valley Electric Association also will be held in that city. Because of the war it was deemed desirable to hold these meetings concurrently in order to conserve time and transportation for those interested in attending both. Headquarters for both meetings will be in the Hotel Continental.

Both organizations, desiring to be of the greatest possible service to the war effort, have assembled papers for presentation and discussion relating so far as practicable to the problems of the electrical industry during wartime. Each organization will have a separate program except for two joint sessions, as indicated, which will appear in both programs. The AIEE South West District includes nine Sections and 14 Student Branches in the states of Missouri, Arkansas, Kansas, Oklahoma, Texas, and New Mexico. The MVEA operates in the

states of Iowa, Nebraska, Missouri, Kansas, and Oklahoma.

JOINT SESSIONS

Especial attention is called to the two joint sessions of AIEE and MVEA for members and guests. The opening session on Wednesday morning will be devoted to a broad outline of the problems before these organizations and their members at the present time. The second joint session on Thursday afternoon will be devoted to the presentation and discussion of one of the most important matters before the country today, namely, the conservation of critical materials which are so badly needed in the war effort. Opportunity will be afforded for discussion to bring out helpful ideas relating to these subjects.

SPECIAL FEATURES FOR STUDENTS

Several of the nearby engineering schools have signified their intention of substituting attendance at the technical meeting and Student Branch conference for their usual

inspection tours which now are impossible because of wartime restrictions. The features arranged especially for students are:

1. A student session arranged by Professor W. F. Gray, chairman, District committee on student activities, will be held on Wednesday afternoon. The program will be in charge of the students and several student papers will be presented.

2. Arrangements have been made for student consultations with industry representatives. The purpose is to give students an opportunity to ask questions and to familiarize themselves with the requirements and opportunities in some of the fields of electrical engineering. The industries and representatives are listed in the program.

3. Each student who registers will be taken to the Thursday noon luncheon by a member of the AIEE. This will afford a splendid opportunity for the students to become acquainted with the older members of the electrical industry and to learn of AIEE affairs from the several talks to be given by officers of the Institute.

4. Certain inspection trips have been arranged particularly for students who will attend the meeting. They are as follows:

Kansas City Power and Light Company Lighting Institute

Kansas City Power and Light load dispatching room and operating building

Kansas City, Kans., generating plant

Kansas City, Kans., water works

Other trips also may be arranged by the time of the meeting.

The personnel of the inspection trips committee is: A. E. Bettis, chairman; J. A. Dailey; H. A. Howerly; A. L. Mullergren; W. J. Squire.

South West District Technical Meeting

Wednesday, April 28

8:00 a.m. Registration

9:30 a.m. General Session (AIEE-MVEA)

Address of welcome: "Kansas City in Wartimes." L. P. Cookingham, city manager, Kansas City, Mo.

Address: "What the AIEE Is Doing to Aid the War Effort." E. T. Mahood, vice-president, South West District, AIEE

Address: "What the MVEA Is Doing to Aid the War Effort." Arthur L. Mullergren, president, Missouri Valley Electric Association

Address: "The Engineer and the War." Harold S. Osborne, president, AIEE

Address: "Electrical Indicating Instruments in Wartimes." Harold L. Olesen, assistant sales manager, Weston Electrical Instrument Corporation

2:00 p.m. Student Session

A COMPARATIVE STUDY OF THE RATIONALIZED AND UNRATIONALIZED M.K.S. UNIT SYSTEM. G. L. Johnson and V. J. McKale, University of Kansas

ROUTINE TESTING OF RESIDENTIAL WATT-HOUR METERS. J. G. McDonald, Kansas State College

THE OPERATION OF SINGLE-PHASE WATT-HOUR METERS. Franklin Fansher, University of Missouri

REVISIONS OF THE ELECTRICAL CODE DUE TO THE WAR EFFORT. L. V. Randle, Southern Methodist University

2:00 p.m. Electrical Machinery

DP.* OILOSTATIC GENERATOR LEADS. C. E. Bennett, The Okonite Company

DP.* CONSERVATION OF CRITICAL MATERIALS IN TRANSFORMER DESIGN AND APPLICATION. J. K. Hodnette, Westinghouse Electric and Manufacturing Company

DP.* EFFECT OF CONTROL ON THE CHARACTERISTICS OF D-C SERIES AND SHUNT MOTORS. A. A. Merrill, General Electric Company

DP.* NORMAL AND EMERGENCY LOADING OF POWER TRANSFORMERS. H. B. Keath and W. Godin, Wagner Electric Corporation

DP.* GRAPHIC SOLUTIONS IN UNBALANCED TRANSFORMER LOADING. C. M. Lovell, Moloney Electric Company

6:30 p.m. Dinner Arranged by MVEA

Thursday, April 29

7:30 a.m. Breakfast Meeting of Student Branch Counselors

7:30 a.m. Breakfast Meeting of Student Branch Officers

9:00 a.m. Clinic on Section Operations and Management

9:30 a.m. Student Consultations With Industry Representatives

R. L. Baldwin has arranged for a group of men to be available with whom students who wish can confer. These men are listed in the adjoining column.

● PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.

● ABSTRACTS of most papers appear elsewhere in this issue.

● PRICES and instructions for procuring advance copies of these papers accompany the abstracts. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at

Industry	Representative
Aviation.....	Howard K. Morgan, T.W.A.
Communication.....	C. H. Weiser, Southwestern Bell Telephone Company
Consulting Engineering....	R. L. Baldwin, Burns and MacDonnell Engineering Company
Electrical Manufacturing....	George Fiske, General Electric Company
Power and Light Operating..	G. O. Brown, Kansas City Power and Light Company
Radiobroadcasting.....	Arthur B. Church, Midland Broadcasting Company
Transportation.....	J. A. Parkinson, Atchison, Topeka, and Santa Fe Railroad Company

SECTION OPERATION AND MANAGEMENT

Delegates from the various Sections in the District are expected to attend the clinic that will be conducted by C. W. Mier of Dallas, Tex., starting at 9:00 a.m. on Thursday. Mr. Mier recently was nominated for Director of the Institute. In addition to the delegates, it is hoped that past officers

DISTRICT EXECUTIVE COMMITTEE MEETING

The District executive committee meeting will be held at 10:30 a.m. on Thursday and in addition to considering the report from the clinic on Section operation and management, will discuss matters relating to AIEE activities throughout the District.

Table I. Hotel Rates

	Prevailing Rates (With Bath)		
	Single	Double	Twin Beds
Continental			
Headquarters Hotel	\$2.50-\$4.00	\$3.50-\$5.00	\$4.00-\$7.00
Muehlebach	3.25-7.00	4.50-8.00	5.50-9.00
Pickwick	2.50-4.00	3.50-6.00	4.50-6.00
Phillips	2.50-5.00	4.00-8.00	5.00-8.00
President	2.75-5.00	4.00-6.50	5.00-7.00

and active members of Sections will attend in order to participate in the discussion. Certain questions relating to Section operation and management will be presented for discussion. Charts and displays of material will be used. This offers an opportunity for Sections to bring up questions, the discussion of which might be helpful to other Sections. It is expected that views will be crystallized on as many of these questions as practicable so that the conclusions of the conference may be presented to the District executive committee, which will meet immediately afterward.

District Secretary R. G. Kloeffer is arranging an agenda.

LUNCHEON AND DINNERS

AIEE members and guests are invited to the MVEA dinner Wednesday evening and may purchase tickets at the registration desk.

There will be a luncheon Thursday noon for AIEE members and guests. A. E. Bettis, vice-president of the Kansas City Power and Light Company, will preside and brief talks will be made on Institute matters by the national officers, as indicated on the program. A feature of this

luncheon will be student attendance. Each senior member will bring a student as his guest, thus offering the students an opportunity to get acquainted with the older members.

A dinner for Thursday evening is being arranged by an AIEE committee. It will be for men only and the dinner will be followed by a talk. MVEA members are invited and may purchase tickets at the registration desk.

REGISTRATION

Members who receive an advance registration card by mail should fill in and return the card promptly. This will save time on arrival at the meeting, as badges for advance registrants will be prepared in advance. No registration fee will be charged for members, enrolled students, and the immediate families of members. There will be a \$2.00 registration fee for all other nonmembers.

HOTEL RESERVATIONS

The hotels and registration committee, C. G. Roush, chairman, 101 West 11th Street, Kansas City, Mo., is doing everything possible to provide hotel accommodations for those who will attend. It is believed that adequate accommodations will be available. Members and guests should write directly to the hotel of their choice as early as possible for accommodations.

In Table I are given the rates for the Hotel Continental, meeting headquarters, and several other hotels within a convenient distance.

Tentative Technical Program and Features

the meeting cannot be assured. Only numbered papers are available in pamphlet form.

● **COUPON** books in \$5 denomination are available for those who may wish this convenient form of remittance.

● **PAPERS** regularly approved by the technical program committee ultimately will be published in "Transactions"; many will appear in "Electrical Engineering."

Each of these men will be in a separate room from 9:30 a.m. on the morning of April 29 to talk with any student or group of students who care to come and talk with him about the conditions, prospects, and future in his particular industry. The talks will be entirely informal and students are welcome to come and go as they please. These men will all do their best to give the student any information desired.

9:00 a.m. Communications

DP.* DALLAS-SAN ANTONIO INTERCITY TOLL CABLE TO PROVIDE COMMUNICATION FACILITIES TO MEET WAR NEEDS IN TEXAS. G. A. Dyer, Southwestern Bell Telephone Company

DP.* TEACHING ULTRAHIGH-FREQUENCY TECHNIQUES. E. W. Hamlin, University of Texas

DP.* COMMUNICATIONS FOR CIVILIAN DEFENSE. O. S. McDaniel, Southwestern Bell Telephone Company

43-72. TRAIN COMMUNICATION. L. O. Grondahl and P. N. Bossart, Union Switch and Signal Company (Presentation by title)

10:30 a.m. District Executive Committee Meeting

12:00 m. AIEE Luncheon

After the luncheon the following national officers will make informal talks on AIEE and civic affairs: P. L. Alger, chairman, technical program committee; H. H. Henline, national secretary; F. J. Meyer, director.

2:00 p.m. Symposium on Critical Materials and Equipment (AIEE-MVEA)

Address: "The Organization and Function of the Conservation Division of the War Production Board." H. M. MacDougall, War Production Board

Address: "Conservation of Critical Materials." H. S. Osborne, president, AIEE

Address: "Conservation of Critical Materials in the Telephone Industry." C. W. Nystrom, Southwestern Bell Telephone Company

Address: "AIEE Guides for the Selection and Operation of Electrical Equipment." J. R. North, chairman, standards committee, AIEE

Address: "Emergency Measures to Increase Output of Generating Equipment." A. C. Monteith, chairman, committee on power generation, AIEE

6:30 p.m. Dinner for men only, and address

Arranged by AIEE

Friday, April 30

9:00 a.m. Selected Topics

DP.* WARTIME TRENDS IN ARC WELDING. G. C. Quinn, Allis-Chalmers Manufacturing Company

DP.* SAFETY ENGINEERING INSTRUCTION IN OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE. A. Naeter, Oklahoma A. & M. College

43-74. INDUSTRIAL CONTROL: DYNAMIC BRAKING OF A D-C SHUNT MOTOR AND LOAD. G. F. Leland and L. T. Rader, General Electric Company

DP.* STANDARDS AND FUNDAMENTALS OF AMPLIDYNE PRACTICE. F. E. Crever, General Electric Company

DP.* INDUCTIVE HEATING IN SUBSTITUTE FERROUS SECTIONS USED IN SWITCHGEAR. S. C. Killian, Delta Star Electric Company

9:00 a.m. Transportation

43-75. ADVANTAGES OF HIGH-SPEED TRACTION MOTORS. C. A. Atwell, Westinghouse Electric and Manufacturing Company

DP.* WARTIME OPERATING EXPERIENCES AND PRACTICES IN KANSAS CITY. L. L. Davis, Kansas City Public Service Company

DP.* MAXIMUM UTILIZATION OF TRANSIT EQUIPMENT. G. M. Woods, Westinghouse Electric and Manufacturing Company

DP.* OPERATING EXPERIENCES WITH TROLLEY COACHES IN ST. JOSEPH. F. Norman Hill, St. Joseph Railway, Light, Heat, and Power Company

*DP: District paper; no advance copies are available; not intended for publication in *Transactions*.



Skyline of Kansas City, Mo., where the South West District technical meeting, April 28-30, 1943, will be held

If satisfactory arrangements cannot be made directly with the hotels, members may write to Mr. Roush. Certain hotels conveniently located with rates appropriate for students have been selected. It is suggested that student counselors be consulted by students who expect to attend and that the counselors in turn communicate with Mr. Roush in case they need any assistance in finding suitable accommodations.

GENERAL INFORMATION

In keeping with the spirit of this meeting, no special entertainment will be provided.

An information desk will be maintained in the lobby to assist out-of-town members in arranging for tickets to shows and dances, of which Kansas City affords a wide and interesting variety. It is expected that members will make up their own parties.

COMMITTEES

District Meeting:

E. T. Mahood, vice-president South West District; R. G. Kloeffler, secretary, South West District; A. T. Campbell, P. C. Ellis, W. F. Gray, I. T. Monseth, R. Randall, G. G. Roush, P. H. Underwood, C. V. Waddington.

Meetings and Papers:

V. P. Hessler, chairman; M. E. Bretschneider, A. T. Campbell, R. W. Gaskins, L. R. Hammond, H. P. Heafer, E. A. Heath, J. Lewis Jones, R. M. Kerchner, H. H. Robison, W. E. Slemmer.

Future AIEE Meetings

District Technical Meeting

Pittsfield, Mass., April 8-9, 1943

District Technical Meeting

Kansas City, Mo., April 28-30, 1943

National Technical Meeting

Cleveland, Ohio, June 21-25, 1943

National Technical Meeting

Salt Lake City, Utah, September 2-4, 1943

Student Activities:

R. L. Baldwin, chairman; D. D. Clarke, W. F. Gray, R. G. Kloeffler, R. J. W. Koopman, M. P. Weinbach.

Publicity and Attendance:

A. T. Campbell, chairman; C. C. Cornelius, L. H. Schultz.

Finance:

George Fiske, chairman.

Hotels and Registration:

C. G. Roush, chairman; A. F. Hartung, S. H. Pollock.

Luncheon and Dinner:

P. C. Ellis, chairman; L. L. Davis, S. M. DeCamp, R. L. Frisby, J. E. Launder, C. M. Lytle.

H. A. Johnston Named AIEE Advertising Manager

H. A. Johnston has been appointed AIEE advertising manager, succeeding the late C. A. Graef (*EE, Feb. '43, p. 73*). He has had a well-rounded experience in technical and industrial advertising, and recently resigned the position of advertising manager of the Triplex Machine Tool Corporation, New York, N. Y., to assume his new duties.

Mr. Johnston has a knowledge of marketing, merchandising, and research as well as an understanding of technical and engineering magazine publishing and advertising. For a number of years he was vice-president of the Sachs Industrial and Technical Advertising Company, a former New York advertising agency. He has served also as advertising manager of *Fire and Water Engineering* and as eastern advertising manager of *Municipal Engineering Magazine*.

He was born in Brooklyn, N. Y., and has been identified with the advertising profession during his entire business career. He attended Mount Hermon School and Rutgers University. Upon leaving college, he was associated with the advertising department of the SKF Ball Bearing Company and the New York Non-Fluid Oil Corporation.

Standard Pronunciation of "Ignitron" Urged

The newly organized AIEE committee on electronics, as its first official act in the field of standardization, has asked Thomas Spooner (F '29) to comment on the pronunciation of the word "ignitron." There have arisen two different pronunciations of the word, which leads to confusion. Mr. Spooner is chairman of the subcommittee on electronics of the standards co-ordinating committee 7 of the AIEE standards committee. His comments follow.

There are thousands of young engineers and others who will meet the term "ignitron" for the first time each year, and anything that can be done to assist them in remembering the device and the nature of its operation is well worth while. When the word first was coined and agreed to by the inventor and the original manufacturer, it was written "ignitron," to indicate that the "i" should be pronounced as "eye" and that the accent should fall on the second syllable. The purpose was to convey the idea of igniting the arc by means of an ignitor. The pronunciation with the short "i" and the accent on the first syllable does not convey readily the impression of ignition. (I hope no one will suggest that ignition applies only to combustion, because the term "ignitron" is here to stay.) This second pronunciation undoubtedly came about from the too slavish following of rules of pronunciation. In this instance the rules should be ignored.

It is inadvisable to have two pronunciations, since it may be thought by the uninitiated that two different devices are being discussed when both pronunciations are used, which frequently happens at discussions during AIEE meetings. Moreover, it may appear to the layman that the follower of one or the other pronunciation does not know what he is talking about if he cannot even pronounce correctly the name of the apparatus which he is discussing.

sing. To eliminate confusion and assist the novice in remembering the device, let us standardize on "ignitron."

There is also a spelling difficulty which frequently arises. The ignition device in the ignitron is spelled ignitor (not igniter).

SECTION

Aircraft Group Being Formed by Los Angeles Section

The AIEE Los Angeles Section is engaged in the formation of an aircraft group to provide a medium for the interchange of ideas and the discussion of problems pertaining to electricity in aircraft. This is the first group in this field to be established by an Institute Section. Interest in the aircraft phase of electrical engineering as a result of the widespread aircraft industry in the area of the Los Angeles Section has given impetus to the establishment of the new group, first specialized technical division to be set up by this Section. It is reported that the San Diego Section is forming a similar group.

The Los Angeles Section recently modified its bylaws to facilitate the formation of specialized groups. Plans include provision for the election of additional officers known as divisional vice-chairmen of the Los Angeles Section, to be elected as needed. Each divisional vice-chairman will form a divisional committee, which will arrange, through the regular machinery of the Section, for as many programs as required in the specialized field.

The formation of groups interested in special phases of electrical engineering within AIEE Sections is not new. A number of Sections already have technical groups on power, transportation, illumination, and communication. In 1934 a plan was proposed to increase member participation in specialized technical group work within the Sections. An outline of this plan appears in an item entitled "Technical Committee Activities Proposed for Sections and Districts," (*EE*, Apr. '34, p. 637). After the plan was discussed by various committees and at various conventions (*EE*, Aug. '34, p. 1232; Aug. '35, p. 900; Aug. '36, pp. 930-2), the proposal was incorporated in the following resolution, adopted by the board of directors on May 25, 1936:

RESOLVED: That the Sections be encouraged by all officers of the Institute and by the technical program committee and the national technical committees in particular to take a greater part in the technical activities of the Institute through such proper channels as they may select, examples being the formation of Section technical committees, the holding of specialized technical group meetings, the sponsoring of specific technical courses, and similar arrangements which have been used successfully or may be worked out in the future.

In an effort to stimulate further interest in establishing the aircraft group, the Los Angeles Section meeting held February 9, 1943, was devoted to electricity in aircraft. The program featured talks by Gilbert F. Burnett, staff electrical engineer of the

Lockheed Aircraft Corporation, who spoke on "Development of Electrical Apparatus in Aircraft"; Charles McCabe, electrical engineer for the Consolidated Aircraft Corporation, who spoke on "Information Required for Installing Electrical Equipment in Aircraft"; and Fred Foulon (A '30) chief of equipment for the Douglas Aircraft Company, who spoke on "Radio Noise Elimination in Aircraft." Interest in electrical aspect of aircraft was indicated by an attendance of over 300 at this meeting.

Washington Section Meets

A capacity audience at the February 9 meeting of the Washington, D. C., Section of AIEE heard a talk on "Power for War" by C. M. Ripley, world traveler, author, and lecturer representing the General Electric Company. The program also included a motion picture, produced by the Westinghouse Electric and Manufacturing Company, showing the Japanese attack on Pearl Harbor and American industry's answer—mass production; and a travelogue motion picture in color of the Skagit River (Oreg.) Development in the Pacific Northwest. The program was preceded by a dinner at the Harrington Hotel.

ABSTRACTS

TECHNICAL PAPERS previewed in this section will be presented at the AIEE North Eastern district technical meeting, Pittsfield, Mass., April 8-9, and the South Western district technical meeting, Kansas City, Mo., April 28-30, 1943, and are expected to be ready for distribution in advance pamphlet form within the current month. The initials NE at the end of an abstract indicate that the paper will be presented at the North Eastern district meeting, SW that the paper will be presented at the South West district meeting. Copies may be obtained by mail from the AIEE order department, 33 West 39th Street, New York, N. Y., at prices indicated with the abstract; or at five cents less per copy if purchased at AIEE headquarters or at the meeting registration desk.

Automatic Stations

43-64—A New Control System for Automatic Parallel Operation of Load Ratio Control Transformers; S. Minneci (A '38), S. B. Farnham (M '42). 20 cents. The successful parallel operation of transformers equipped with automatic load-ratio control and line-drop compensation requires that stability of operation be insured. In addition, experience has shown that it is frequently highly desirable that other automatic features be included which will contribute toward operating flexibility and which will permit switching transformers in and out of parallel operation without disturbing the voltage level at the load center or causing an excessive initial circulating current at the instant of paralleling. This paper discusses the conditions which make these added fea-

tures desirable, and presents a new control system whereby they all may be secured readily. In this new system, load current and circulating current are made to flow in separate paths in the control circuit, and each produces its effects independently, thereby insuring stable operation and maintaining the desired load-center voltage level. This separation of the load and circulating current, in conjunction with a modification in the closing circuit of the paralleling circuit breaker, also makes possible the avoidance of excessive initial circulating current when the breaker is closed. The simplicity and effectiveness of this arrangement in providing a fully automatic means for meeting all the anticipated operating requirements recommends its use in many applications. (NE).

Electrical Machinery

43-65—Use of Equivalent Annual Ambient Temperature in Overloading Transformers and Voltage Regulators; M. S. Oldacre (M '42). 15 cents. The "Interim Report on Guides for Overloading Transformers and Voltage Regulators," prepared by the transformer subcommittee of the AIEE Committee on electrical machinery and published in *AIEE Transactions*, volume 61, 1942, September section, pages 692-4, referred to the use of equivalent annual ambient temperature instead of daily average ambient temperature in determining the overload possibilities of transformer apparatus. Previous methods for determining this equivalent temperature have been difficult to apply and therefore the Interim Report did not include a discussion of this point. The object of this paper on the use of equivalent annual ambient temperature in overloading transformers and voltage regulators is to point out a relatively simple method of calculating the equivalent annual ambient temperature from readily available climatological data for various locations in the country and also how this information may be applied in determining the overload possibilities of the transformer apparatus. (NE).

43-71—New Developments on Potential Transformer Design; G. Camilli (M '27). 15 cents. The paper describes new designs of potential transformers in which volumes and weights have been reduced to a small fraction of the conventional designs, the factor of safety increased and this without any sacrifice in the accuracy characteristics. The designs are based on a novel method of arranging and insulating the high voltage winding. The new units are completely sealed (with no gaskets) and because of their small volume, it is economically advantageous to use special insulating liquid such as "Pyranol". Because of their small size and weight, it is possible to install these transformers in the bus structure near the high-voltage lines. (NE).

Industrial Control

43-74—Industrial Control: Dynamic Braking of a D-C Shunt Motor and Load; *G. F. Leland, L. T. Rader (A'34). 20 cents.* This paper presents an analysis of a shunt motor and attached load under dynamic braking conditions when the shunt field is held constant at full field. Three types of load are considered: (a) constant torque, (b) torque varying directly as the speed, together with a frictional component independent of the speed, (c) torque varying as the square of the speed together with a frictional component independent of the speed. For each case, equations are derived for current and time as a function of initial kinetic energy in the rotating system, initial watts in the dynamic braking resistor, and initial breaking current. For case (a) a family of curves is plotted where the ratio of friction to initial braking torque is varied from 0 to 100 per cent. For cases (b) and (c) families of curves are plotted for initial braking current equal to 100, 150, and 200 per cent of full load current, when the parameter, which is a ratio of friction to full load torque, varies from 0 to 100 per cent. All curves are plotted with dimensionless co-ordinates so that they may be applied to any size system. An example is given showing the use of the equation for case (a). (SW).

Land Transportation

43-67—The Sorocabana Railway Electrification; *Durval Muxlaert. 30 cents.* The Sorocabana Electrification is noteworthy in that the railroad is a meter-gauge line run largely on wood fuel. The lack of suitable national coal or oil sources and the increasing difficulty of obtaining wood fuel led the railway to electrify its line between Sao Paulo and Santo Antonio. Rolling stock is outstanding in that the locomotives will be the most powerful 3,000-volt narrow gauge units ever built. The multiple-unit cars are the first 3,000-volt meter-gauge units to be used. The distribution system is designed to minimize the use of steel supports. Steel must be imported, and locally made concrete poles are to be utilized extensively. The power supply system using 3,000-volt mercury-arc rectifiers is the first installation in this hemisphere to use rectifier conversion with regenerative braking on locomotives. Regenerated energy returned to the substations will be dissipated in resistors roof-mounted at the several stations. (NE).

43-72—Train Communication; *L. O. Grondahl (M'42), P. N. Bossart. 25 cents.* The term, train communication, has gained use to designate communication between vehicles on a railway track and between such vehicles and stationary points, such as offices and towers. It has to do in all cases with railroad operation, and not with provision of communication facilities for passengers. A short history of the attempts to provide train communication is given. A

system of telephonic communication in which a carrier current of low frequency is used is described. The rails on which the vehicles are located are used for the primary transmission line. The carrier frequency lies between 5,000 and 10,000 cycles. The paper discusses means of coupling to the track, the transmission characteristics of the track, the assistance that is gained from adjacent line wires, the characteristics of the transmitting and receiving apparatus, the current levels used in the track at the receiving and at the transmitting ends, and various devices that have been resorted to in order to provide a satisfactory transmission of intelligence under extremely difficult conditions. The relation of the communication system to railway operation and to other means of communication is discussed. (NE, SW).

43-75—Advantages of High-Speed Traction Motors; *C. A. Atwell (M'43). 15 cents.* Recent high-speed traction motors have certain inherent advantages over their slower speed predecessors. This paper lists these advantages and gives data on them, such as reduced size and weight, better commutation, simplified mechanical construction and mounting, and resulting simplified maintenance. The evolutionary trend toward higher-speed light traction motors started in the 20's but showed the most progress in the 30's. The recent designs that are available and in service on city and interurban transit vehicles and on some Diesel-electric and mining locomotives have saved large amounts of copper and steel. For example, the saving of over 600 tons of copper has been effected on motors for Presidents' Conference Committee street cars alone. The smaller and lighter weight motors make possible the construction of the modern vehicles on which they are used. (SW).

Power Generation

43-66—The Frequencies of Natural Power Oscillations in Interconnected Generating and Distribution Systems; *Reinhold Rüdenberg (M'38). 30 cents.* The transient distribution of power among the generator units, lines and consumers of interconnected systems, after any disturbance of the steady state, depends upon the characteristic data of the various elements of the entire network. Usually oscillations of power and of system frequency occur, which may be detrimental to the performance of the system or its parts. A method is developed for determining from a small number of well-known data the spectrum of natural frequencies of these oscillations and the distribution of their power swings among generators and motors. Generally a single very low frequency develops, determined by the interaction of all the speed governors and impressed upon the entire system. A group of higher frequencies arises, determined by the action of the synchronous generators and mainly disturbing these machines proper. A third group of highest frequencies is caused by

the many induction motors, the inter-oscillations of which, however, are damped rapidly. Rules are derived in the paper for tuning the various elements in order to keep the more dangerous oscillations within narrow limits, improving the overall stability of the system. (NE).

Power Transmission, Distribution

43-73—Thermal Rating of Overhead Line Wire; *Myron Zucker (M'36). 25 cents.* Although normally of little practical importance, the thermal limitations of transmission and distribution circuits now are brought to the fore by scarcity of copper and aluminum. In this paper, new studies are added to thoroughly analyzed published and unpublished data. These are applied to the two major divisions: permissible temperatures to prevent the wire from deteriorating unduly and to preserve clearances; and temperatures that the wire will attain considering both the basic thermal relationships and the probable weather conditions under normal and emergency operation. On some of these points, detailed data are given, for example, information on time for annealing copper is taken from 37 authorities and put into simple form for engineering use. Other aspects, such as preservation of clearances and correlation of weather data, depend so much on local conditions that this paper suggests methods of treating them and gives examples, rather than trying to set a formula. (NE).

Protective Devices

43-69—Interim Report on Application and Operation of Circuit Breakers and Switchgear; *subcommittee on circuit breakers, switches, and fuses of the AIEE committee on protective devices. 15 cents.* The present war emergency makes it essential that maximum use be made of existing equipment and that a minimum amount of critical material be used for new equipment. To this end this report has been prepared as an aid to those involved in the application and operation of circuit breakers and switchgear. This report covers equipment of the following types:

1. A-c power circuit breakers above 600 volts, both indoor and outdoor. (AIEE Standard 19).
2. Air disconnecting switches. (AIEE Standard 22).
3. Switchgear assemblies. (AIEE Standard 27).

The report is a revision of the "Preliminary Report on Guides for Application and Operation of Circuit Breakers and Switchgear," by the subcommittee on breakers, switches, and fuses of the AIEE committee on protective devices, which was presented at the AIEE national technical meeting, January 28, 1943, New York, N. Y. It includes suggestions for making the maximum use of circuit breakers and switchgear by considering the effect of ambient temperature, artificial cooling, emergency loading, notification of existing equipment, and simplification of new installations. (NE).

43-70—Overvoltage Protection of Current Transformer Secondaries and Associated Circuits; R. H. Kaufmann (M'41), G. Camilli (M'27). 20 cents. It long has been recognized that excessive potentials may be developed in current transformer secondaries under unusual conditions, such as open circuits. Recent experience discloses that dangerous overvoltages (several thousand volts) may be produced in the absence of circuit faults as a result of normal switching operations on circuits containing lumped capacitance. A simple procedure for circuit analysis and evaluation of approximate voltage magnitude for the switching transient case is reported. For easy reference, there are included tables of calculated secondary voltage magnitudes covering a broad range of application. Under certain conditions, overvoltage protection is desirable and important. Aside from the potential hazard to life, current transformer circuit insulation may be damaged, yet it may not be immediately evident. Performance at normal rated current may not be noticeably impaired, yet serious failures occur in the presence of fault current flow, thus nullifying the action of current actuated protective relays. The characteristics of a new overvoltage protector expressly designed for current transformer protection are presented. With this device current transformer secondary voltages are limited to moderate values. The protector is

small and compact, and easily applied to existing as well as new current transformer installations. The characteristics are permanent, not affected by repetitive operation, and result in negligible ratio error in the normal operating current range. (NE).

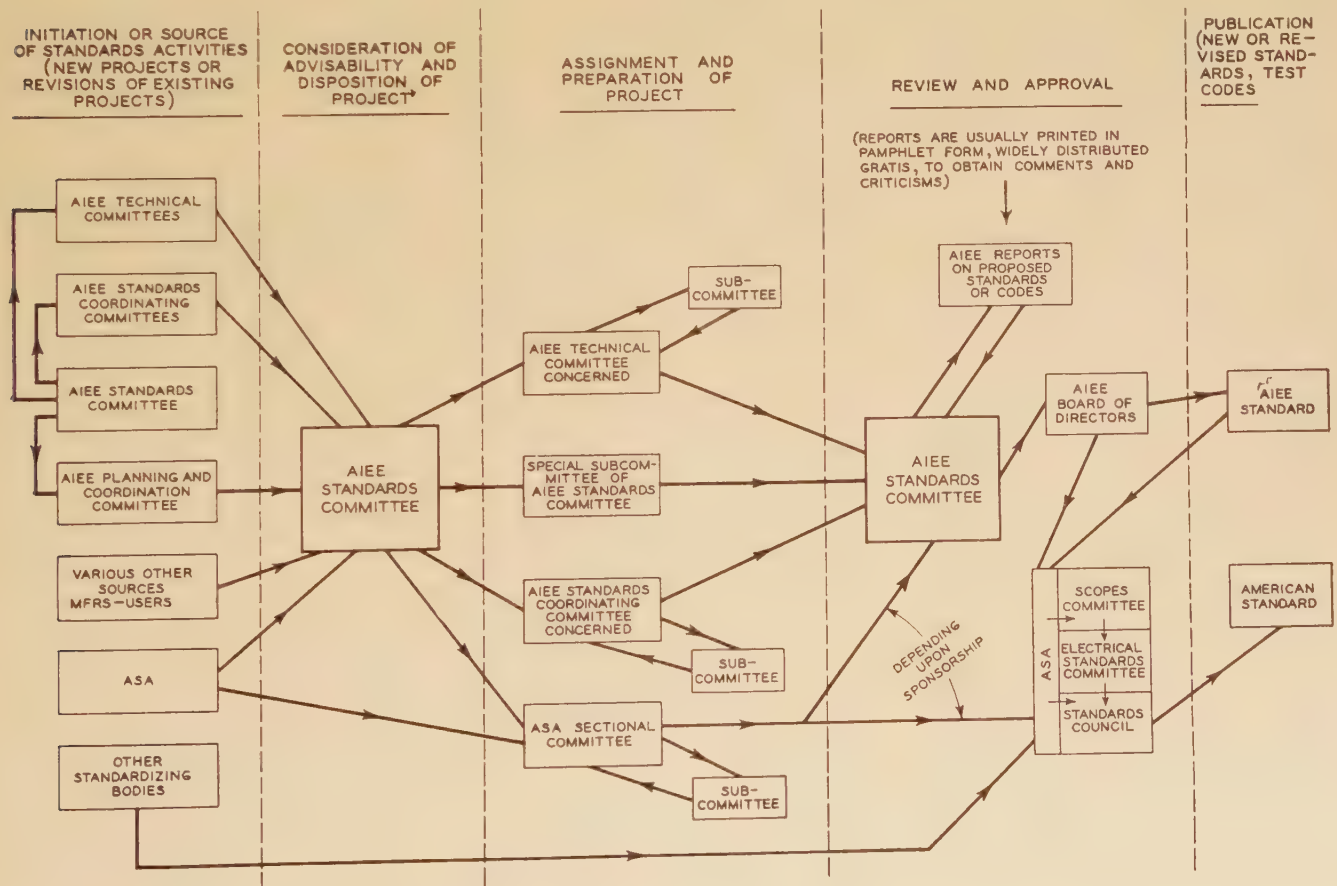
STANDARDS . . .

Procedure in Development of Standards Clarified

The AIEE standards committee is faced frequently with situations showing that many men engaged in various phases of standards development do not have a clear picture of the procedure involved. Standardization work is carried on by various technical committees of the Institute, by standards co-ordinating committees, and by sectional committees of the American Standards Association under the sponsorship of the AIEE. The diagram of standards activities, reproduced here indicates the inception or source, how the various projects are considered and assigned, and the steps taken in formulating standards and obtaining their review and approval prior to publication in final form as AIEE and American Standards. Certain special situations have been excluded in order not to complicate the diagram unnecessarily.

PERSONAL

E. S. McConnell (A'29, M'36) engineer with the Edison Electric Institute, New York, N. Y., has resigned to become product manager for aeronautical wires and cables with the United States Rubber Company, New York, N. Y. After receiving his bachelor of science degree in electrical engineering from the University of Minnesota in 1924, he was employed by the Chicago, Milwaukee and St. Paul Railway, Milwaukee, Wis., and Tacoma, Wash., as special apprentice and assistant engineer, from 1924 to 1928. During part of 1926 and 1927 he held the Strathcona Fellowship in transportation engineering at Yale University. In 1928 he was for a term instructor in railway mechanical engineering at Pennsylvania State College, State College. Later that year he was assistant electrical engineer for the American Brass Company, Waterbury, Conn., and from 1929 to 1933, was district engineer for the Anaconda Wire and Cable Company, Chicago, Ill. After a six-month period as sales engineer for the Air Conditioning Corporation, Chicago, Ill., he returned to the Anaconda company at Hastings-on-Hudson, N. Y., as mechanical and electrical designer of overhead transmission and distribution lines. He joined the Copper Wire Engineering Association,



Procedure in development of AIEE standards and test codes

Washington, D. C., in 1938 and in 1940 the Edison Institute. He holds several patents.

Burke Smith (A '17, M '28) transmission engineer, Illinois Bell Telephone Company, Chicago, retired on March 31, 1943. Born March 26, 1878, at Forrest, Ill., he received the degrees of bachelor of science in 1899, and doctor of philosophy in 1904 from Yale University. He was an instructor at Northwestern University, Evanston, Ill., during 1900-01, at Yale University, New Haven, Conn., during 1902-03, and at Purdue University, Lafayette, Ind., from 1904 to 1907. In 1903 he joined the New York (N. Y.) Telephone Company as an engineering assistant. From 1907 to 1911 he was an engineering assistant with the Chicago (Ill.) Telephone Company. He retained that position with the Central Group of Bell Telephone Companies until 1919, when he was made transmission engineer. Since 1920 he has been with the Illinois Bell Telephone Company. He is the author of a number of articles on mathematics, engineering, and education. He is also a fellow of the American Association for the Advancement of Science, and a member of the American Mathematical Society and Phi Beta Kappa.

S. L. Foster (A '96, M '96) superintendent of overhead lines, Market Street Railway Company, San Francisco, Calif., has retired. Born March 16, 1863, in Sacramento, Calif., he was graduated from Harvard University in 1885 with the degree of bachelor of arts. He was employed by the Thomson-Houston Electric Company, Lynn, Mass., from 1885 to 1888 as superintendent of installation in Michigan, Nevada, and California. In 1888 he became superintendent and general manager from the Home Electric Company, Bay City, Mich. He had charge of the construction of the first electric railroads in northern California for the Oakland (Calif.) Consolidated Railway, and the San Francisco, San Mateo Railway from 1890 to 1893. He began a period of 49 years' continuous service for the Market Street Railway in 1893. For many years he was chief electrician for railroad construction and maintenance. Of late years he worked on distribution problems and acted as a general consultant.

W. V. Kahler (M '39) chief engineer with the Illinois Bell Telephone Company, Chicago, has been appointed assistant vice-president. He received the degree of bachelor of science in mechanical engineering from the University of Missouri and joined the Bell Telephone Laboratories, New York, N. Y., as an engineering assistant in 1922. He was transferred to the Illinois Bell Telephone Company in 1924, becoming division equipment engineer in 1927, and division plant supervisor in 1930. From 1930 to 1937 he served as engineer for the American Telephone and Telegraph Company, New York, N. Y. He was made

maintenance engineer in 1937. In 1938 he returned to the Illinois company as chief engineer. Since 1940 he has been also assistant director and construction secretary with the National Defense Advisory Committee.

L. H. Beebe (A '42) superintendent of tests, shop and test department, Southern California Edison Company Limited, Alhambra, has been named manager of the shop and test department of that company. At the outset of his career, he was employed by the General Electric Company, Schenectady, N. Y., from 1910 to 1914, as testman and salesclerk. He spent the years, from 1914 to 1918, as a meterman in the employ first, of the Los Angeles (Calif.) Gas and Electric Company and then the Nevada-California Power Company, Tonopah and Goldfield. He has been connected with the test department of the Southern California Edison Company since 1918, when he started as a polyphase testman. From 1920 to 1925 he was a technical assistant. In 1925 he was made assistant superintendent of the test department, and in 1928 superintendent of tests.

H. B. Robinson (M '38) operating superintendent of the Carolina Light and Power Company, Raleigh, N. C., has been elected a vice-president of that company. Mr. Robinson received his bachelor of engineering degree from North Carolina State College. From 1924 to 1927 he was an engineering assistant with the Brooklyn (N. Y.) Edison Company. During 1927 he worked for the Carolina Power company as relay engineer. He joined the Electric Bond and Share Company, New York, N. Y., as an assistant engineer in 1927 and in 1932 returned to the Carolina Power company as engineer in charge of substation maintenance. Substation construction was added to his responsibilities in 1935. He was made substation engineer for design, construction, and maintenance in 1937, and one year later became operating superintendent.

C. E. Young (A '09) assistant engineer of operation, Pacific Gas and Electric Company, San Francisco, Calif., has retired. Born July 16, 1874, in Santa Cruz County, Calif., he began his electrical career as third engineer in the employ of the Mutual Electric Light Company, San Francisco, from 1898 to 1900. He worked as marine machinist in 1901 for the Union Iron Works, San Francisco. From 1902 to 1904 he was shift foreman in the hydroelectric generating station of the Standard Electric Company, San Francisco. He installed electrical machinery and apparatus from 1904 to 1906 for the Diamond Match Company, Chico, Calif. In 1906 he entered the employ of the Pacific Gas and Electric Company. Until 1908 he served as division foreman, and in that year was made division superintendent. He held that position until 1914, when he joined the operation department.

J. H. Foote (A '18, F '32) supervising engineer of Commonwealth and Southern Corporation, Jackson, Mich., has been named to the Board of Registration for Architects, Professional Engineers, and Land Surveyors, of Michigan for a seven-year period. Mr. Foote was graduated from Michigan State College in 1914. Since 1915 he has been associated with affiliated companies now forming the Commonwealth and Southern Corporation. In various capacities he has been responsible for the design and construction of power distribution systems for the Eastern Michigan Power Corporation, Consumers Power Company, Stevens and Wood, Inc., and Allied Engineers, all of Jackson. In 1931 he was made supervising engineer for the Commonwealth and Southern Corporation.

G. E. Quinan (A '18, F '18) chief engineer of the Puget Sound Power and Light Company, Seattle, Wash., has been appointed chief consulting engineer with responsibility for all engineering activity of the company. Since 1911, when he became light and power operating superintendent for the Seattle (Wash.) Electric Company, its predecessor, he has been with the Puget Sound company. From 1913 to 1915 he was superintendent of the light and power department of that company. He was made engineer in charge of electrical and mechanical engineering in the Seattle district in 1915. In 1917 his duties were extended to properties in Bellingham, Everett, and Tacoma under the management of Stone and Webster, Philadelphia, Pa. He has been chief electrical engineer since 1919.

John Finlaw (A '35) assistant plant superintendent of the Schuylkill station of the Philadelphia (Pa.) Electric Company, has been appointed superintendent of the station. He entered the employ of the Philadelphia Electric Company in 1912. Before becoming assistant superintendent in 1940, he held the positions of assistant station operator in 1912, substation operator in 1913, generating station operator in 1914, chief electrician 1916, and shift engineer in 1917. In 1919 he was made assistant load dispatcher and, in 1922 load dispatcher. He became supervisor of load dispatchers in 1928, and assistant chief load dispatcher in 1931.

C. F. Nagle (A '39) general superintendent of the Scranton (Pa.) Electric Company, has been appointed general manager of that company. Before joining the Scranton company he worked, from 1904 to 1918, for the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., the Pennsylvania Coal Company, and the Citizens Electric Illuminating Company, Pittston, Pa. Entering the employ of the Scranton company in 1918 as an engineer, he became superintendent of transmission and distribution in 1920. In 1926 he was made general superintendent.

Burkewood Welbourn (M '26) chief engineer, British Insulated Cables, Ltd., Prescot, England, has retired from that position to become consulting engineer and a member of the company's board of directors. Mr. Welbourn has been with British Insulated Cables, Ltd., since 1897, when he was appointed an assistant engineer. In 1901 he was made chief construction engineer, and in 1927 chief engineer. He received the honorary degree of master of engineering from the University of Liverpool in 1935, and is a member of the Institution of Electrical Engineers, London, England.

K. P. Applegate (A '14) general manager of the Hartford (Conn.) Electric Light Company, has been elected a vice-president of the company also. Receiving the degree of electrical engineer from Rensselaer Polytechnic Institute in 1912, he joined the Hartford Light company as a draftsman. In succession he became inspector of electrical apparatus in 1913, power sales engineer in 1914, and manager of the appliance and motor sales department in 1916. He was general purchasing agent from 1917 to 1929 when he became general manager.

John J. Anderson, Jr. (A '40) who joined the AIEE headquarters staff in 1940 to assist in the work of publishing the book "American Standard Definitions of Electrical Terms" has been granted a leave of absence to serve with the United States Naval Reserve. He will receive training on the USS *Prairie State* and upon completion will be commissioned an Ensign. Previous to his affiliation with the AIEE staff Mr. Anderson was employed by the United States Rubber Company, New York, N. Y.

W. J. McKeen (A '11, M '36) engineer of inside construction in the City Lighting Department of Seattle, Wash., recently retired. He was born on July 26, 1873, in Ontario. From 1898 to 1904 he did experimental work in electrical engineering and telephony in a private laboratory. Since 1904 when he became foreman on inside construction, he has been associated with the Seattle Lighting Department. In 1918 he was made engineer of inside construction with the duty of assisting the superintendent.

H. D. Moreland (A '35, M '41) district manager of Westinghouse X-ray Company, Portland, Oreg., has been made manager of the X-ray products, agency, and specialties department of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. He received the bachelor of science and master of science degrees in electrical engineering from the University of Oregon in 1930 and 1932. Since 1933 he has been employed by the Westinghouse X-Ray Company.

G. A. Mills (M '18) construction engineer, engineering department of the Central Power and Light Company, Corpus Christi, Tex., has been made superintendent

of power plants. Mr. Mills has been associated with the Central Power company since 1939. Before that he held executive positions in a number of middle western utility companies. He was a charter member and first chairman of the AIEE Dallas Section, which was formed in 1928.

H. B. Stoddard (A '27) assistant engineer in the system engineering department, Consolidated Edison Company of New York (N. Y.), has been given a wartime leave of absence to become instrument engineer in the mechanical department of the General Cable Corporation, Perth Amboy, N. J. Mr. Stoddard has been with Consolidated Edison company since 1925 as general tester, and later junior engineer; in 1930 he was made assistant engineer.

J. J. Fiske, Jr. (A '42) student engineer with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been made electronic control specialist for that company in the Los Angeles, Calif., area. He graduated from the University of California with the degree of bachelor of science in 1941 and entered the general sales department of the Westinghouse Electric and Manufacturing Company in that year.

William Wilson (M '23) retired assistant vice-president of Bell Laboratories Inc., New York, N. Y., has been awarded the medal of honor of the Institute of Radio Engineers for, "his achievements in the development of modern electronics, including its application to radio telephony, and for his contributions to the welfare and work of the Institute." For a fuller biography of Mr. Wilson see *Electrical Engineering*, February 1943, page 74.

Eugene Vinet (A '13, M '25) formerly electrical designer with Ebasco Services, Inc., New York, N. Y., has become special engineering assistant to the vice-president of W. L. Maxson Corporation, New York, N. Y. Mr. Vinet had been associated with Ebasco Services since 1941. Before that he was for a year executive secretary of the National Electrical Manufacturers Association.

W. S. Smith (A '34) traffic engineer, in the traffic engineering division of the South Carolina State Highway Department, Columbia, has been appointed to do traffic research work at Yale University, New Haven, Conn. Mr. Smith has been with the South Carolina Highway department since he received the degree of master of science in electrical engineering from the University of South Carolina, in 1933.

T. O. Eaton (A '28) switchgear specialist of the General Electric Company, Philadelphia, Pa., has been appointed assistant manager of sales, power transformer section, in the Pittsfield, Mass., works of that company. He entered the drafting department of the company's Schenectady, N. Y.,

works in 1925. He was transferred to Pittsburgh, Pa., in 1930 as switchgear specialist and to Philadelphia in 1938.

H. F. Dart (A '20, M '26) of the electronics tube engineering department, Westinghouse Electric and Manufacturing Company, Bloomfield, N. J., has been elected secretary of the New York section of the Institute of Radio Engineers and not national secretary of the Institute as was reported in *Electrical Engineering*, February 1943, page 76.

T. C. Clarke (A '35, M '42) district manager of the Northern Electric Company, Ltd., Vancouver, B. C., has been elected to the board of directors of that company. He joined the Northern Electric company in 1919 as sales engineer and was made a district sales manager (1928) for Manitoba. He was transferred to British Columbia in 1932.

C. R. Hanna (A '24, M '39) manager of the electromechanical department, research laboratories, of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been awarded a citation of individual production merit by President Roosevelt for developing a device that increased the effectiveness of American tanks.

W. P. Graham (A '02, F '23) chancellor emeritus of Syracuse (N. Y.) University, has been awarded the honorary degree of doctor of laws by that University. He also has been elected a councilman-at-large of the city of Syracuse. A fuller biography of Doctor Graham was published in *Electrical Engineering*, October 1942, page 531.

F. J. Sullivan (A '17, M '41) division plant superintendent for the Michigan Bell Telephone Company, Saginaw, has been promoted to assistant general plant manager. He has been with the telephone company since 1905, and became division plant superintendent in 1919.

Dean A. Powers (A '42) formerly engineer with the Public Utilities Commission of Ohio, Columbus, has been appointed to the research staff of Battelle Memorial Institute, Columbus, Ohio. He will assist in electrochemical and electrometallurgical research.

J. F. Harrison (M '40) chief engineer of the Mississippi Power and Light Company, Jackson, has been elected president of the Mississippi Society of Professional Engineers. **J. B. Fountain** (A '35) engineer, has been elected secretary of the Mississippi society.

T. H. Crosby (M '37) district manager, Canadian Westinghouse Company, Ltd., Vancouver, B. C., has been appointed a member of the executive committee of the Association of Professional Engineers of British Columbia by the provincial government.

W. H. Mansfield (A '27) Louisiana plant superintendent, Southern Bell Telephone

Company, New Orleans, La., has been appointed general plant manager. Mr. Mansfield has been with the telephone company since 1911.

F. F. Crocker (A '39) local agent of the California Electric Power Company, Palm Springs, has been made superintendent of that company's newly created district at Palm Springs. Mr. Crocker had been local agent since 1932.

J. D. Lawrence (A '25) district manager for the Appalachian Electric Power Company at Williamson, W. Va., has been transferred to Logan, W. Va., as division manager. Mr. Lawrence has been district manager since 1928.

H. R. Zimmerman (M '40) superintendent of the electrical department, Gary (Ind.) Sheet and Tin Mills, Carnegie-Illinois Steel Corporation, has been elected a director of the Association of Iron and Steel Engineers.

E. L. Robinson (A '28, M '30) sales manager of the Crescent Insulated Wire and Cable Company, Trenton, N. J., has been named chairman of the product scope committee of the National Electrical Manufacturers Association.

W. L. Smith (A '23) safety engineer of the Department of Water and Power of the City of Los Angeles, Calif., has been elected to the executive committee of the National Safety Council, Public Utilities Section.

L. G. McNeice (M '37) engineer and manager of the Orillia (Ont.) Water, Light and Power Commission, has been elected a district director of the Association of Municipal Electrical Utilities.

D. C. Green (M '26) chairman of the board of the Cleveland Pneumatic Tool Company, Ohio, has been awarded the honorary degree of doctor of engineering by Purdue University.

E. B. Whitman (M '34) partner in the firm of Whitman, Requardt and Smith, Baltimore, Md., has been elected president of the American Society of Civil Engineers for 1943.

W. C. White (A '23, M '30) director of the electronics laboratory, General Electric Company, Schenectady, N. Y., has been named a member of the board of directors of the Institute of Radio Engineers.

A. W. Bradt (M '26) secretary and general manager of the Hamilton (Ont.) Hydro-Electric System, has been elected a director of the Association of Municipal Electrical Utilities.

J. E. Teckoe, Jr. (M '29) manager of the Hydro-Electric Commission of Niagara Falls, Ont., has been elected a district director of the Association of Municipal Electrical Utilities.

T. H. Hogg (M '31, F '38) chairman and chief engineer, of The Hydro-Electric

Power Commission of Ontario, Toronto, has been elected honorary president of the Ontario Municipal Electric Association.

L. R. Milburn (A '20, F '39) electrical engineer, Great Lakes Steel Corporation, Ecorse, Mich., has been elected a director of the Association of Iron and Steel Engineers.

Haraden Pratt (A '15, F '37) vice-president and chief engineer, Mackay Radio and Telegraph Company, New York, N. Y., has been elected secretary of the Institute of Radio Engineers.

R. B. Chandler (M '38) manager of the Public Utilities Commission, Port Arthur, Ont., has been elected president of the Association of Municipal Electrical Utilities.

C. J. Barker (M '37) major, Engineers Corps, United States Army, is now a lieutenant colonel on special duty in Great Britain.

G. A. Neal (A '19) president of the Sioux City Gas and Electric Company, Iowa, has been elected president of the Iowa Utilities Association.

C. A. Leland (M '27) president of the Des Moines Electric Light Company, Iowa, has been elected second vice-president of the Iowa Utilities Association.

OBITUARY • • • •

Stanton S. Hertz (A '17, M '27, F '39) vice-president and assistant to the president of the Copperweld Steel Company, Glassport, Pa., died on February 20, 1943. Born in Montgomery, Ala., on June 17, 1891, he received the degrees of bachelor of science in electrical engineering in 1911 and electrical engineer in 1926 from the Alabama Polytechnic Institute. From 1911 to 1916 he was foreman in the dynamo and transformer test departments of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. In 1916 he was employed as an electrical engineer by the Electrical Engineering and Manufacturing Company, Pittsburgh, Pa. He served as an officer in the United States Army Corps of Engineers from 1917 to 1919, when he resumed his position as engineer and director of the Electrical Engineering company. In 1920 he was appointed district manager for the Stackpole Carbon Company, Pittsburgh, Pa., and later that year joined the Copperweld Steel Company as head of the electrical engineering department of the engineering division. He held the position of chief engineer in charge of the engineering division from 1927 to 1936. In 1936 he was named executive director of the Copper Wire Engineering Association, Washington, D. C. He returned to the Copperweld company in 1941 as vice-president. He was a member of the International Association of Electrical Inspectors, the International Association of Municipal Electricians, and the Ameri-

can Society of Testing Materials. From 1939 to 1942 he served on the AIEE membership committee.

Andrew Newton Outzen (A '14) superintendent of natural gas receiving station and the River Rouge manufacturing plant of the Michigan Consolidated Gas Company, Detroit, died August 26, 1941. He was born April 30, 1885, at Carlton, Wis., and was graduated from the University of Wisconsin with the degree of bachelor of science in electrical engineering in 1910. From 1908 to 1914 he was electrician for the University of Wisconsin, Madison. In 1912 he entered the engineering department of the Madison (Wis.) Gas and Electric Company, becoming superintendent of its gas works in 1914. In that same capacity he worked for the Binghamton (N. Y.) Gas Company from 1915 to 1917. In 1917 he joined the Michigan Consolidated Gas Company as production foreman at Station A in Detroit. In 1918 he was made superintendent and in 1919 superintendent of manufacturing. In 1920 he became superintendent of construction and operation at Station J. He was first associated with the company's River Rouge plant in 1924 as superintendent of design. In rapid succession he served as certifying engineer on construction in 1925 and superintendent in 1926. He returned to the position of superintendent of Station J in 1927, and was again superintendent of the River Rouge plant from 1929 to 1933. He held both positions from 1933 to 1937. In 1936 he was appointed superintendent of the natural gas receiving station.

Andrew John O'Reilly (A '03) retired construction safety engineer of St. Louis, Mo., died on January 27, 1943. Born on January 13, 1863, in Montgomery County, Mo., he was graduated from Washington University in 1888 with the degree of bachelor of engineering. After operating his own electrical engineering firm for a short time, he entered the employ of the Municipal Electric Light and Power Company, St. Louis, Mo., as assistant to the general manager to superintend electrical construction. In 1890 he was made supervisor and chief electrical engineer. From 1903 to 1905 he was chief of fire prevention for the Louisiana Exposition. He acted as president of the Board of Public Improvement, St. Louis, Mo., from 1905 to 1909. After 1909 he worked as a consulting engineer. He had charge of the construction of the St. Louis (Mo.) station of the Mississippi River Power Distribution Company in 1912 and 1913. As a safety engineer he was associated with the National Fire Prevention Board. He served on the Public Service Commission of the State of Missouri from 1921 to 1925. From 1926 to 1932 he was chief electrical engineer for the Department of Public Safety of the City of St. Louis (Mo.). He was also a member of the American Association for the Advancement of Science, and the American Society of Mechanical Engineers.

Elmer H. Schwarz (A '03, M '18) consulting engineer of the firm of Schwarz, Hughes, and McCarthy, New York, N. Y., died on February 21, 1943. Born in Rochester, N. Y., on February 23, 1880, he received the degree of bachelor of philosophy from the Sheffield Scientific School of Yale University in 1901. From 1901 to 1903 he worked in the testing, drafting, and a-c engineering departments of the General Electric Company, Schenectady, N. Y. His career in patent work began in 1904, when he joined the Patent Control Board, New York, N. Y., which handled the patent interests of the General Electric Company and the Westinghouse Electric and Manufacturing Company. From 1911 to 1940 he was a partner in the firm of Hammer and Schwarz, New York, N. Y., consulting electrical and mechanical engineers. In 1940 he became a member of the firm of Schwarz, Hughes, and McCarthy. He held a number of patents and was also a member of the American Society of Mechanical Engineers, the American Society of Refrigerating Engineers, and the Society of Automotive Engineers. For many years he served as a director of the Henry Street Settlement, New York, N. Y.

Robert Stuart Stewart (A '96, M '00) consulting electrical engineer of La Jolla, Calif., died November 11, 1942. Born September 10, 1869, in Detroit, Mich., he received the degrees of bachelor of arts in 1891, and master of arts and electrical engineer in 1894 from Princeton University. In 1894 he began a six-year affiliation with the Public Lighting Commission of Detroit (Mich.). He supervised the installation of cables and terminals on the street lighting system, and later took general charge of the distribution system. He resigned in 1896, and after a year of study in Europe, joined the Westinghouse Electric and Manufacturing Company, as erecting engineer in charge of that company's exhibit at Omaha, Neb. During 1899 he supervised construction for the Westinghouse Company near Philadelphia, Pa. From 1900 to 1904 he was employed by the British Westinghouse Electric and Manufacturing Company, Manchester, England, as engineer in charge of the design of all d-c generators and motors. He was engaged in the purchase and consolidation of several power companies in Essex County, Ont., from 1904 to 1918. Since 1918 he had practiced as a consulting engineer.

Martin Schiff (M '20, F '39) chief engineer, Century Electric Company, St. Louis, Mo., died on February 15, 1943. He was born on October 7, 1890, in New York, N. Y., and received the degree of mechanical engineer from Cornell University in 1912. That year he entered the employ of the Diehl Manufacturing Company, Elizabeth, N. J., as test engineer, and in 1913 became assistant engineer for the Ideal Electric and Manufacturing Company, Mansfield, Ohio. He was a member of the firm of Schiff and Schroeder, New York, N. Y.,

manufacturers of hoisting machinery, during 1914. In 1915 he returned to the Ideal Electric company. Following service in the United States Navy during World War I, he was engaged in a-c motor design for the Electro Dynamic Company, Bayonne, N. J., during 1920. From 1920 to 1929 he was assistant chief engineer and chief engineer with Roth Brothers and Company, Chicago, Ill. He was made assistant chief engineer and assistant to the president for the Imperial Electric Company, Akron, Ohio, in 1929. In 1933 he joined the Century company as chief engineer.

Albert Holloway Reiber (A '21, M '35, F '40) engineer of development and research, Teletype Corporation, Chicago, Ill., died on February 1, 1943. He was born in New York, N. Y., on April 13, 1894, and was graduated from the Stevens Institute of Technology with the degree of mechanical engineer in 1916. Since 1916 he had been active in the development of printing telegraph equipment, in which connection he was issued numerous patents. From 1916 to 1920 he was employed by the Western Union Telegraph Company as a development engineer. In 1920 he joined the Kleinschmidt Electric Company, Long Island City, N. Y., which became the Mokrum-Kleinschmidt Corporation in 1925 and the Teletype Corporation in 1928. Until 1922 when he became manager of sales and engineering, he served as sales engineer. He was transferred to Chicago, Ill., as development engineer in 1925, and in 1928 was made apparatus engineer and assistant to the vice-president. In 1930 he was appointed engineer of development and research. He was a member of Tau Beta Pi.

Thomas Reeve Rosebrugh (A '91) professor emeritus of electrical engineering of the University of Toronto, died on January 24, 1943. Born in Ontario, on June 6, 1866, he received the degrees of bachelor of arts in 1877 and master of arts in 1893 from the University of Toronto. The honorary degree of doctor of science was conferred upon him by that University in 1936. He joined the faculty of the school of practical science of the University of Toronto, Ont., as a lecturer in electrical engineering in 1889, and was appointed head of the department of electrical engineering a few years later. He remained in that position until his retirement in 1936. In collaboration with his father he invented, in 1894, one of the early "phantom circuit" systems for telephone and telegraph communication. He was the author of papers on electrochemistry, transmission calculations, and quantum determinants. He was an organizer of the Toronto Section of AIEE, a charter member of the Toronto section of the Institute of Radio Engineers, and a fellow of the Royal Society of Canada.

Joseph Francis Stockwell (A '03) executive vice-president of the Keystone Tele-

phone Company, Philadelphia, Pa., died on January 28, 1943. Mr. Stockwell, who was born on February 29, 1880, at Portland, Maine, graduated from the Drexel Institute of Technology. He entered the engineering department of the Keystone company in 1900 as a draftsman. In 1902 he was made wire chief of the main exchange. From 1903 to 1906 he was on leave of absence to aid in developing the Ontario Telephone Company, Oswego, N. Y., and the Independence Telephone Company, Syracuse, N. Y. In 1906 he returned to the Keystone company, becoming a director, executive vice-president, and general manager. He also held the positions of director and vice-president of the Camden (N. J.) and Atlantic Telephone Company and the Pennsylvania Independent Telephone Association. He was a director of the Chamber of Commerce and Board of Trade of Philadelphia, as well as a member of the Telephone Pioneers of America, and a number of historical societies.

John G. Barry (A '03) retired honorary vice-president of the General Electric Company, Schenectady, N. Y., died on March 4, 1943. Born on December 4, 1863, Mr. Barry joined the Thomson-Houston Electric Company, Lynn, Mass., in 1890, and began a lifetime affiliation with that company and its successor, the General Electric Company. In 1894 he transferred to the railway department at Schenectady, N. Y. He was appointed department manager in 1907 and in 1917 assumed the additional duties of general sales manager. In 1922 he was named vice-president charged with supervision of the apparatus sales organization. He retired with an honorary vice-presidency in 1935. For many years he served on the executive committee of the American Electric Railway Association. He had served also as a member of the Schenectady Board of Education and as fuel administrator for the Schenectady district during World War I. He was also a member of the Schenectady Chamber of Commerce.

Delbert C. Meyer (M '29) toll equipment engineer, Bell Telephone Laboratories, New York, N. Y., died on February 2, 1943. Born in Cleveland, Ohio, on August 6, 1890, he received the degrees of bachelor of arts from Western Reserve University and bachelor of science from the Case School of Applied Science in 1912. He immediately entered the engineering department of the Western Electric Company, Chicago, Ill., where in 1917 he was placed in charge of the design of telephone central office equipment. In 1920 he was transferred to the New York (N. Y.) engineering department of that company. When the Bell Telephone Laboratories were formed in 1925, he became head of the toll equipment department, responsible for solving the design problems for many parts of the telephone systems, cable and coaxial systems, and all telegraph systems. He published articles on equipment and held

several patents. Mr. Meyer was serving on the AIEE membership committee for 1942-43.

Henry O'Brien Frederick Hayward (A '39) captain in the Royal Canadian Armed Forces, died on January 15, 1943, in Poona, India. He was born on March 30, 1913, in Vancouver, B. C., and was graduated from Brasenose College, Oxford University, with a bachelor of arts honors degree in engineering in 1935. From 1932 to 1937 he was associated with Metropolitan-Vickers Electrical Company, Manchester, England, where he was employed first as a student apprentice, later becoming designer of a-c and d-c machines and mining equipment, and sales representative. During 1935 he headed an Oxford University expedition to explore Greenland. In 1937 he entered the electrical construction and maintenance department of the British Columbia Electric Railway Company, Vancouver, as assistant test engineer. He was a graduate member of the Institute of Electrical Engineers, London, England, and a fellow of the Royal Geographical Society.

James Thomas Holmes (M '24) engineer with the Frink Corporation, Long Island City, N. Y., died on February 12, 1943. He was born on May 6, 1880, in Washington, D. C. From 1899 to 1907 he worked as electrical helper, journeyman, and foreman, on the electrical construction in buildings in New York, N. Y. He was an electrical inspector for the City of New York during 1907 and 1908 and for the Metropolitan Life Insurance Company, New York, N. Y., from 1908 to 1910. As superintendent of installation and construction, he joined I. P. Frink, Inc., New York, N. Y., in 1910. He was made chief electrical engineer in 1913. In 1935 he resigned his position to become president of Mitchell-Vance Company, New York, N. Y. In 1939 he returned to the Frink Corporation where he worked on special lighting problems. He served on the AIEE committee on the production and application of light from 1933 to 1936.

Ludwig Kallir (M '29) of the British Electrical and Allied Industries Research Association, London, England, died on January 7, 1943. Born November 11, 1874, in Leipzig, Germany, he attended the Technische Hochschule, Vienna, Austria. He taught at that institution from 1897 to 1900. In 1900 he joined the Union Elektrizitats-Gesellschaft, Vienna, the Austrian organization of the Allgemeine Elektrizitats-Gesellschaft. He served as director responsible for the department of power generation and transmission from 1910 to 1938. In the latter year he was made a member of the board of directors of the union. He was president of the Elektrotechnischer Verein in Vienna and of the Austrian committee of electrical engineers. In 1939 he moved to London,

and in 1941 he became associated with the British Electrical and Allied Industries Research Association.

Lauren Dale Nordstrum (A '04, M '13) designing engineer in the d-c motor generator department, General Electric Company, Fort Wayne, Ind., died February 1, 1943. He was born February 23, 1878, in Rainsville, Ind., and was graduated from Purdue University in 1901 with the degree of bachelor of science in electrical engineering. He was engaged as an instructor of physics at Purdue University, Lafayette, Ind., from 1901 to 1905. In 1905, as an engineer in the test department, he began a 37-year association with the General Electric Company. The same year he was transferred to the position of design engineer in the apparatus department. In 1918 he was made assistant engineer of that department. In 1925 he became engineer in the d-c apparatus section, where he was responsible for improvements in electric dynamometers and hydraulic dynamometers.

John A. Gallagher (A '42) equipment engineer, Southern Bell Telephone and Telegraph Company, Atlanta, Ga., died November 11, 1942. He was born June 21, 1885, at St. Louis, Mo. From 1906 to 1917 he worked for the Kinloch Telephone Company, St. Louis, Mo., the Abilene (Tex.) Telephone Company, and the Atlanta Telephone Company. In 1917 he was employed as equipment engineer in the engineering department of the Western Electric Company, Chicago, Ill. He became equipment supervisor for the Southern Bell company in Savannah, Ga., in 1920. Transferring in 1925 to that company's Florida division at Jacksonville he held the positions of equipment engineer, division equipment engineer, and maintenance supervisor until 1941. In the latter year he moved to the chief engineer's office, Atlanta, Ga., as equipment engineer.

Arthur C. Flory (M '26) manager of the steam turbine department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., died on March 1, 1943. Born February 14, 1883, he graduated from Lehigh University in 1906 with the degree of mechanical engineer. He immediately entered the steam turbine department of the Allis-Chalmers company as a draftsman. In 1909 he became engineer in the department. From 1912 to 1919 he was assistant manager. Since 1919 he had held the position of manager of the department. The steam turbine department was responsible for the engineering and sales of all steam turbine units. He was also a member of the American Society of Mechanical Engineers. From 1938 to 1941 he served on the AIEE Lamme Medal committee.

Edward Engel Hilbert (A '42) engineer, motor engineering department, Wagner

Electric Corporation, St. Louis, Mo., died on February 26, 1943. Born in St. Louis, Mo., on May 20, 1913, he was graduated from Washington University in 1935 with the degree of bachelor of science in electrical engineering. In 1936 he entered the employ of the Wagner company, where he worked on the design and writing of specifications for integral horsepower motors.

MEMBERSHIP ••

Recommended for Transfer

The board of examiners, at its meeting on March 18, 1943, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Boehne, E. W., research engineer, General Electric Company, Philadelphia, Pa.
Dobson, W. P., chief testing engineer, Hydroelectric Power Commission of Ontario, Toronto, Ont., Canada.
Hughes, M. C., head of Electrical Engineering department, Agricultural and Mechanical College of Texas, College Station, Texas.
Lane, R. K., president, Public Service Company of Oklahoma, Tulsa, Okla.
Logan, K. H., chief, Underground Corrosion Section, National Bureau of Standards, Washington, D. C.
Thomas, J. B., president and general manager, Texas Electric Service Company, Fort Worth, Texas.
6 to grade of Fellow

To Grade of Member

Arnot, Clarence, assistant superintendent, British Columbia Electric Railway Company, Vancouver, B. C., Canada.
Backer, C. M., senior engineer, Radio Signal Corps, Wright Field, Dayton, Ohio.
Barnes, F. C., switchgear engineer, Canadian General Electric Company Limited, Toronto, Ont., Canada.
Bennett, H. G., electrical engineer, Durham Public Service Company, Durham, N. C.
Braam, A. E., engineer, Northern Indiana Public Service Company, Hammond, Ind.
Dixon, H. S., electrical test engineer, Douglas Aircraft Company, Los Angeles, Calif.
Evans, R. L., electrical design engineer, Mason and Hanger Company, Baraboo, Wis.
Fink, G. R., switchgear section, General Electric Company, Philadelphia, Pa.
Goldsborough, S. L., design engineer, Westinghouse Electric and Manufacturing Company, Newark, N. J.
Halman, T. R., relay engineer, Detroit Edison Company, Detroit, Mich.
Hanna, W. M., assistant to electrical engineer, Consolidated Gas Electric Light and Power Company, Baltimore, Md.
Kisner, A. G., central station engineer, General Electric Company, Philadelphia, Pa.
Kresser, J. V., district engineer, Westinghouse Electric and Manufacturing Company, San Francisco, Calif.
LaPierre, C. W., development engineer, General Electric Company, Schenectady, N. Y.
Light, P. H., application engineer, General Electric Company, Schenectady, N. Y.
Love, R. M., electrical engineer, Durham Public Service Company, Durham, N. C.
Lynn, C., manager, D.C. generator engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Mars, Nick, laboratory engineer, Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Moody, A. F., division testing and regulating chief, Western Union Telegraph Company, Dallas, Texas.
Muller, H. N., central station engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Newhouse, R. C., member of technical staff, Bell Telephone Laboratories, Inc., New York.
Piepho, E. E., electrical engineer, Detroit Edison Company, Detroit, Mich.
Powell, J. B., engineer, General Electric Company, New Haven, Conn.
Smith, E. L., electrical engineer, The Firestone Tire and Rubber Company, Akron, Ohio.
Smith, R. J., vice-president, American Electrical Construction Company, Inc., Philadelphia, Pa.
Sykes, C. S., district engineer, Philadelphia Electric Company, Philadelphia, Pa.
Titter, B. K., chief electrical engineer, Nicaro Nickel Company, New York.

Weinheimer, C. M., in charge of mechanical division,
Detroit Edison Company, Detroit, Mich.
28 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical District. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before April 30, 1943, or June 30, 1943, if the applicant resides outside of the United States or Canada.

To Grade of Member

Benjamin, E. C., M. W. Kellogg Co., New York, N. Y.
Berry, W. L., Hughes Aircraft Co., Culver City, Cal.
Blum, H. L., Royal Switchboard Co., Brooklyn, N. Y.
Boorzhinsky, N. P. (Member re-election), Moloney Elec. Co., St. Louis, Mo.
Breckenridge, F. W. E. & M. Co., Mansfield, O.
Brodie, L. S., Canadian Army, Directorate of Mechanical Maintenance, MGO Branch, NDHQ, Ottawa, Ont.
Burden, B. C., U. S. Ind. Tel. Co., Washington, D. C.
Cockrell, W. D., Gen. Elec. Co., Schenectady, N. Y.
Coller, C., Penn. Power & Light Co., Shenandoah, Pa.
Crawford, K. B., Rural Elec. Adm., St. Louis, Mo.
Doherty, J. P., Quality Elec. Co., Los Angeles, Cal.
Eldridge, T. I., Jr., Electric Service Supplies Co., Philadelphia, Pa.
Farmer, S. G., Elec. Constr. Co., Ltd., Bushbury Engg. Works, Bushbury, Wolverhampton, Eng.
Foulk, T. M., Pub. Serv. Co., Denver, Col.
Herzog, E. J., Westinghouse Elec. Int. Co., Caracas, Venezuela, S. A.
Impellitteri, V. J., Bur. of Ships, Navy Dept., Washington, D. C.
Lent, S. (Member), Boston Elev. Ry., Boston, Mass.
Lillyblad, R. H., Camfield Mfg. Co., Grand Haven, Mich.
Mackey, B. R., Cornell Univ., Ithaca, N. Y.
Marchese, V. J., E. I. du Pont De Nemours Co., Wilmington, Del.
Michelsen, J. H., M. W. Kellogg Co., New York, N. Y.
Miller, C. E., Commonwealth Edison Co., Chicago, Ill.
Mundt, A. J., Western Union Tel. Co., New York, N. Y.
O'Connor, R. R., Ill. Bell Telephone Co., Chicago, Ill.
Olken, H., Navy Yard, Washington, D. C.
Pixton, S. W., Mtn. States Tel. & Tel. Co., Salt Lake City, Utah.
Platt, N. L., Cornell Univ., Ithaca, N. Y.
Rigby, W. S., Ordnance Dept., Tank Automotive Center, Detroit, Mich.
Sliter, H. M., Gen. Elec. Co., New York, N. Y.
Steele, D. R., Stone & Webster Engg. Corp., Long Beach, Cal.
Thor, B. V., Canadian Westinghouse Co., Hamilton, Ont.
Underhill, E. M., Cinaudagraph Corp., Stamford, Conn.
White, P. A., Penn. Power & Light Co., Shenandoah, Pa.
Winther, J. B., Dynamatic Corp., Kenosha, Wis.
Wolfe, I. D., Pacific Bridge Co., Pearl Harbor, T. H.
Wright, H. M., A. Reyrolle & Company, Limited, Hebburn-on-Tyne, County Durham, England.
Zink, G. W., Phelps Dodge Copper Prod. Corp., Yonkers, N. Y.
37 to grade of Member

To Grade of Associate

United States and Canada

1. NORTH EASTERN

Adams, L. P., Gen. Elec. Co., Schenectady, N. Y.
Ahern, C. R., Mass. Inst. Tech., Boston, Mass.
Allen, T. E., Gen. Elec. Co., Schenectady, N. Y.
Almasy, G. W., Gen. Elec. Co., Schenectady, N. Y.
Ball, E. G., Bethlehem Steel Co., Lackawanna, N. Y.
Baucorn, I. C., Jr., Gen. Elec. Co., Schenectady, N. Y.
Bentley, A. Y., Mass. Inst. Tech., Cambridge, Mass.
Blum, P. F., Gen. Elec. Co., Lynn, Mass.
Borden, L. L., Gen. Elec. Co., Schenectady, N. Y.
Bornstein, I., Gen. Elec. Co., Schenectady, N. Y.
Broome, J. W., Gen. Elec. Co., Schenectady, N. Y.
Brown, D. R., Gen. Elec. Co., Schenectady, N. Y.
Browne, A. J., Bethlehem Steel Corp., Buffalo, N. Y.
Burwell, T. I., United Ill. Co., New Haven, Conn.
Butler, G. H., Gen. Elec. Co., Schenectady, N. Y.
Caspersen, W. N., Gen. Elec. Co., Schenectady, N. Y.
Chelgren, A. E., Lt. Signal Corps, U. S. Army, Cambridge, Mass.
Chow, W. T., Gen. Elec. Co., Schenectady, N. Y.
Cohn, S. B., Harvard Univ., Cambridge, Mass.
Cooper, O. L., Jr., Gen. Elec. Co., Schenectady, N. Y.

Critchlow, G. F., Cornell Univ., Ithaca, N. Y.
Dean, R. K., Gen. Elec. Co., Schenectady, N. Y.
DesRoberts, H. J., DesRoberts Elec. Co., Lynn, Mass.
Dunham, S. B., Gen. Elec. Co., Schenectady, N. Y.
Flamm, H. F., Gen. Elec. Co., Schenectady, N. Y.
Flower, R. L., Gen. Elec. Co., Schenectady, N. Y.
Frank, E., Curtis-Wright Corp., Buffalo, N. Y.
Friedl, E. M., Gen. Elec. Co., Schenectady, N. Y.
Fritsche, W. O., United Illuminating Co., New Haven, Conn.
Fuegel, E. F., Gen. Elec. Co., Pittsfield, Mass.
Gayer, J. H., Signal Corps, U. S. Army, Cruft Lab., Harvard Univ., Cambridge, Mass.
Geiszler, A. R., Gen. Elec. Co., Schenectady, N. Y.
Glasford, G. M., Mass. Inst. Tech., Cambridge, Mass.
Golombe, S. N., Mass. Inst. Tech., Cambridge, Mass.
Guyer, E. H., Bethlehem Steel Corp., Lackawanna, N. Y.
Haertig, M. M., Gen. Elec. Co., Schenectady, N. Y.
Hall, D. F., Gen. Elec. Co., Schenectady, N. Y.
Hang, D. F., Gen. Elec. Co., Schenectady, N. Y.
Hickey, J. S., Jr., Gen. Elec. Co., Schenectady, N. Y.
Huelsman, A. H., Gen. Elec. Co., Schenectady, N. Y.
Illman, R. W., Mass. Inst. Tech., Cambridge, Mass.
Imm, R. A., Gen. Elec. Co., Schenectady, N. Y.
Jacob, W. R., Gen. Elec. Co., Schenectady, N. Y.
Kessler, G. W., Gen. Elec. Co., Schenectady, N. Y.
Klemm, G. H., Harvard University, Cambridge, Mass.
Koehler, R. A., Gen. Elec. Co., Schenectady, N. Y.
Kratz, E. M., Gen. Elec. Co., Schenectady, N. Y.
Kruesi, W. R., Gen. Elec. Co., Schenectady, N. Y.
Kusko, A., Mass. Inst. Tech., Cambridge, Mass.
Larsen, R. B., Gen. Elec. Co., Schenectady, N. Y.
Lawrence, B. J., Gen. Elec. Co., Bridgeport, Conn.
Leete, B. D., Gen. Elec. Co., Schenectady, N. Y.
Lewis, R. V., Gen. Elec. Co., Schenectady, N. Y.
Light, E. E., Gen. Elec. Co., Schenectady, N. Y.
Love, A. L., III, Gen. Elec. Co., Bridgeport, Conn.
Mauvo, A., Gen. Elec. Co., Schenectady, N. Y.
Mavellin, J. C., Gen. Elec. Co., Schenectady, N. Y.
McClure, R. C., Gen. Elec. Co., Schenectady, N. Y.
McDonnell, J., Gen. Elec. Co., Schenectady, N. Y.
Meloun, C. J., Gen. Elec. Co., Schenectady, N. Y.
Mitchel, W. F., Gen. Elec. Co., Schenectady, N. Y.
Mitchell, F. A., Stromberg Carlson Tel. Mfg. Co., Rochester, N. Y.
Moffett, H. R., Gen. Elec. Co., Schenectady, N. Y.
Morgan, R. C., Gen. Elec. Co., Schenectady, N. Y.
Mullen, F. C. (Associate re-election), Siena College, Loudonville, N. Y.
Myers, R. T., Gen. Elec. Co., Schenectady, N. Y.
Nelson, J. S., Gen. Elec. Co., West Lynn, Mass.
Oakley, W. J., United Illuminating Co., New Haven, Conn.
O'Neil, S. J., Gen. Elec. Co., Schenectady, N. Y.
Owens, B. M., Gen. Elec. Co., Lynn, Mass.
Parker, R. J., Gen. Elec. Co., Schenectady, N. Y.
Peel, J. A., Gen. Elec. Co., Schenectady, N. Y.
Phillips, J. E., Gen. Elec. Co., Schenectady, N. Y.
Popp, F. G., Stromberg Carlson Tel. Mfg. Co., Rochester, N. Y.
Port, R. F. (Associate re-election), Central New York Pr. Corp., Syracuse, N. Y.
Potthoff, E. O., Gen. Elec. Co., Schenectady, N. Y.
Pratt, F. C., Stromberg Carlson Tel. Mfg. Co., Rochester, N. Y.
Ratiff, C. M., Jr., Gen. Elec. Co., Schenectady, N. Y.
Reed, R. I., Gen. Elec. Co., Schenectady, N. Y.
Reilly, T. J., Gen. Elec. Co., Schenectady, N. Y.
Rich, G. S., Gen. Elec. Co., Pittsfield, Mass.
Rove, H. W., Mass. Inst. Tech., Cambridge, Mass.
Rubel, J. H., Gen. Elec. Co., Schenectady, N. Y.
Sanderford, R. M., Jr., Gen. Elec. Co., Schenectady, N. Y.
Schauss, S. L., Cornell Univ., Ithaca, N. Y.
Schneider, H. J., Gen. Elec. Co., West Lynn, Mass.
Scholz, H. K., Gen. Elec. Co., Schenectady, N. Y.
Schroeder, G. W., Gen. Elec. Co., Schenectady, N. Y.
Shoffner, J. M., Harvard Univ., Cambridge, Mass.
Smith, P. J., Gen. Elec. Co., Bridgeport, Conn.
Smith, R. E., Gen. Elec. Co., Schenectady, N. Y.
Snider, G. B., Jr., Gen. Elec. Co., Schenectady, N. Y.
Squier, C. L., Bethlehem Steel Co., Lackawanna, N. Y.
Stavely, E. B., Jr., Gen. Elec. Co., Schenectady, N. Y.
Stone, J. A., Gen. Elec. Co., Schenectady, N. Y.
T'ang, M. C., Gen. Elec. Co., Pittsfield, Mass.
Terrill, S. F., Nash Engr. Co., So. Norwalk, Conn.
Thor, D. D., Gen. Elec. Co., Schenectady, N. Y.
Tillma, J. E., Gen. Elec. Co., Schenectady, N. Y.
Van Horn, I. H., Jr., Mass. Inst. Tech., Cambridge.
Verzuh, F. M., Mass. Inst. Tech., Cambridge, Mass.
Wheeler, B. G., Gen. Elec. Co., Schenectady, N. Y.
Wilcox, G. R., Gen. Elec. Co., Schenectady, N. Y.
Wilson, F. D., Jr., Gen. Elec. Co., Schenectady, N. Y.

2. MIDDLE EASTERN

Anderson, R. L., W. E. & M. Co., East Pittsburgh, Pa.
Arnold, N. E., R. C. A. Mfg. Co., Camden, N. J.
Ballard, R. J., W. E. & M. Co., East Pittsburgh, Pa.
Beers, M. I., Robbins & Myers Inc., Springfield, O.
Behrent, L. F., U. S. Civil Service Comm., Washington, D. C.
Bennett, E. G., Nat. Bureau of Standards, Washington, D. C.
Bradford, E. L., W. E. & M. Co., East Pittsburgh, Pa.
Brewer, E. W., Gen. Elec. Co., Erie, Pa.
Brown, L. D., Gen. Elec. Co., Philadelphia, Pa.
Browning, E. H., Jr., W. E. & M. Co., East Pittsburgh, Pa.
Burdett, J. C., W. E. & M. Co., Lima, O.

Call, R. D., W. E. & M. Co., East Pittsburgh, Pa.
Carr, J. W., W. E. & M. Co., East Pittsburgh, Pa.
Carr, W. J., Jr., Westinghouse Res. Lab., East Pittsburgh, Pa.
Catanzaro, J., Westinghouse Elec. Co., Baltimore, Md.
Chapman, C. W., Gen. Elec. Co., Erie, Pa.
Christensen, W. L., W. E. & M. Co., East Pittsburgh, Pa.
Connelley, R. K., Philadelphia Company, Pittsburgh, Pa.
Crockford, J. B., W. E. & M. Co., Lima, O.
Crowe, P. P., U. S. Engr's, Dayton, O.
Darchuk, W., 4013 Buechner Ave., Cleveland, O.
DeAngelis, F. A., W. E. & M. Co., East Pittsburgh, Pa.
Doerrie, C. C., W. E. & M. Co., East Pittsburgh, Pa.
Duffy, P. A., Jr., W. E. & M. Co., Baltimore, Md.
Ebert, T. E., W. E. & M. Co., East Pittsburgh, Pa.
Evenson, H. J., W. E. & M. Co., East Pittsburgh, Pa.
Feuerriegel, R. G., Gen. Elec. Co., Philadelphia, Pa.
Florence, V. H., Philco Corp., Philadelphia, Pa.
Frink, R. E., W. E. & M. Co., East Pittsburgh, Pa.
Gable, N. P., Sylvania Electric Products, Inc., Emporium, Pa.
Graf, J. H., III, Gen. Elec. Co., Philadelphia, Pa.
Granneman, A. H., Bur. of Ships, Navy Dept., Washington, D. C.
Guroy, J. R., Jr., W. E. & M. Co., Cleveland, O.
Halma, H., R. C. A. Serv. Co., Philadelphia, Pa.
Harris, W. W., Bethlehem Steel Corp., Lebanon, Pa.
Hershel, W. D., Jr., Gen. Elec. Co., Erie, Pa.
Hersfield, S., Philco Radio & Television Corp., Philadelphia, Pa.
Himmer, F., Philco Radio & Tel. Corp., Philadelphia, Pa.
Hoffman, P. A., Naval Research Lab., Bellevue, D. C.
Hofmeister, C. A., Penn. Elec. Coil Corp., Pittsburgh, Pa.
Hogan, A. W., Nat'l Advisory Comm. for Aeronautics, Cleveland, O.
Hoss, G. L., National Advisory Committee for Aeronautics, Cleveland Airport, Cleveland, O.
Hull, R. S., National Cash Register Co., Dayton, O.
Hunt, J. E. (Associate re-election), Philadelphia Elec. Co., Philadelphia, Pa.
Jansen, H. R., W. E. & M. Co., East Pittsburgh, Pa.
Jennings, D. R., Gen. Elec. Co., Erie, Pa.
Johnson, E. J., Navy Dept., Cape May, N. J.
Johnson, O., W. E. & M. Co., Columbus, O.
Jost, J. F., York Ice Machinery Corp., York, Pa.
Kafitz, P. H., Naval Ordnance Lab., Navy Yard, Washington, D. C.
Kershner, R. H., W. E. & M. Co., East Pittsburgh, Pa.
Krichbaum, C. E., U. S. Engineer Office, Wright Field, Dayton, O.
Kunst, J. N., Dravo Corp., Wilmington, Del.
Long, F. E., 5503 Montrose Ave., Altoona, Pa.
Luckie, S. B., III, Gen. Elec. Co., Philadelphia, Pa.
Martin, B. V., W. E. & M. Co., East Pittsburgh, Pa.
Matheson, V. A., W. E. & M. Co., East Pittsburgh, Pa.
McCay, W. S., W. E. & M. Co., East Pittsburgh, Pa.
Monroe, C. J., W. E. & M. Co., Baltimore, Md.
Mowry, N. A., Blaw-Knox Co., Pittsburgh, Pa.
Murdock, H. T., Allis-Chalmers Mfg. Co., Norwood, O.
Nagel, W. I., W. E. & M. Co., East Pittsburgh, Pa.
Norrett, E. J., Gen. Elec. Co., Phila., Pa.
O'Black, E. J., E. I. du Pont De Nemours & Co., Morgantown, W. Va.
Palmer, B. M., Owens-Corning Fiberglas Corp., Newark, O.
Piper, R. W., Jr., W. E. & M. Co., East Pittsburgh, Pa.
Plotkin, M., Proving Center, Aberdeen Proving Ground, Md.
Podhorzer, E., Army Air Force, Wright Field, Dayton, O.
Sangster, G. E., Potomac Elec. Pr. Co., Washington, D. C.
Sauer, R. J., Gen. Elec. Co., Erie, Pa.
Scheerer, P. J., Monongahela West Penn Public Ser. Co., Fairmont, W. Va.
Schmidt, H. J., I-T-E-Circuit Breaker Co., Philadelphia, Pa.
Schnure, F. O., Jr., W. E. & M. Co., East Pittsburgh, Pa.
Schroeder, J. H., Goodyear Aircraft Corp., Akron, O.
Senft, C. E., W. E. & M. Co., East Pittsburgh, Pa.
Slaughter, E. C., Lear Avia, Inc., Piqua, O.
Smith, E. B., W. E. & M. Co., East Pittsburgh, Pa.
Spalding, T. R., Jack & Heintz Inc., Bedford, O.
Spencer, E. G., 2310 Ashmead Place, N. W., Washington, D. C.
Suozzo, J. C., W. E. & M. Co., East Pittsburgh, Pa.
Thomas, G. I., W. E. & M. Co., East Pittsburgh, Pa.
Thompson, A. G., Naval Research Lab., Anacostia Station, Washington, D. C.
Timewell, H. C., British Admiralty Delegation, Washington, D. C.
Trenkle, F. A., W. E. & M. Co., East Pittsburgh, Pa.
Wagner, O., W. E. & M. Co., East Pittsburgh, Pa.
Weedman, W. F., Naval Research Lab., Anacostia Station, Washington, D. C.
Welch, G. H. (Associate re-election), W. E. & M. Co., East Pittsburgh, Pa.
White, G. T., U. S. Naval Reserve, Washington, D. C.
Widlar, W. L., Jr., WGAR Broadcasting Co., Cleveland, O.
Wilhite, J. G., Jr., W. E. & M. Co., East Pittsburgh, Pa.

Williams, J. B., Philco Radio & Television Corp., Philadelphia, Pa.
 Wood, H. O., Philco Radio Corp., Philadelphia, Pa.
 Wulfsberg, A. H., Sylvania Electric Products, Inc., Emporium, Pa.

3. NEW YORK CITY
 Adler, L. L., Radioguide Mfg. Co., New York, N. Y.
 Andrews, C. J., Federal Tel. & Radio Corp., Newark, N. J.
 Bassett, E. D., Chemical Constr. Co., New York, N. Y.
 Bentley, W. A., Radio Corp. of Amer., Harrison, N. J.
 Biehl, F. A., M. W. Kellogg Co., New York, N. Y.
 Bonner, W. F. (Associate re-election), Federal Tel. & Radio Corp., Newark, N. J.
 Bradford, C. E., Sperry Gyroscope Co., Brooklyn, N. Y.
 Brown, A. C., Sperry Gyroscope Co., Brooklyn, N. Y.
 Burger, K. C., Signal Corps, Ground Signal Service, Fort Monmouth, N. J.
 Carter, P. D., Gibbs & Hill, Inc., New York, N. Y.
 Cockerill, F. J., 140 West St., New York, N. Y.
 Collins, G. J., Federal Tel. & Radio Corp., Newark, N. J.
 Conklin, L. E., Gair Carton Inc., Piermont, N. Y.
 Coombs, J. B., Federal Tel. & Radio Corp., Newark, N. J.
 Corning, C. T., Federal Tel. & Radio Corp., Newark, N. J.
 Derganc, W., Office of War Inform., New York, N. Y.
 Dolega, S. J., Con. Edison Co., New York, N. Y.
 Edgill, R. A., New York Tel. Co., New York, N. Y.
 Edwards, R. S., Sperry Gyroscope Co., Garden City, N. Y.
 Elliot, P. J., L. I. Lighting Co., Glenwood Landing, N. Y.
 Ellis, B. T., Jr., Federal Tel. & Radio Corp., Newark, N. J.
 Feeney, C. J., Western Elec. Co., 120 Bway, New York, N. Y.
 Franklin, R. J., The Lumis Co., New York, N. Y.
 Froebel, C. A., Standard Oil Dev. Co., Elizabeth, N. J.
 Game, R. I., Bell Telephone Lab., New York, N. Y.
 Garmany, W. J., Jr., Ward Leonard Elec. Co., Mount Vernon, N. Y.
 Gerbore, A. E., Bell Telephone Lab., New York, N. Y.
 Goodstein, J., Radio Receptor Co., New York, N. Y.
 Gray, J. R., Federal Tel. & Radio Corp., Newark, N. J.
 Hammond, H. M., Sperry Gyroscope Co., Garden City, N. Y.
 Haninger, G. A., Federal Tel. & Radio Corp., Newark, N. J.
 Harrington, C. E., Amer. Tel. & Tel. Co., New York, N. Y.
 Harrison, W., Wilputte Coke Oven Corp., New York, N. Y.
 Hedison, H. D., Jr., Grumman Aircraft Engg. Corp., Bethpage, N. Y.
 Johnson, W. C., W. E. & M. Co., Bloomfield, N. J.
 Jones, A. F., Federal Tel. & Radio Corp., Newark, N. J.
 Kall, A. R., Bell Telephone Lab., New York, N. Y.
 Kaufman, L. L., U. S. Navy Dept., Brooklyn, N. Y.
 Kerwin, E. R., Newark Signal Corps, Inspection Zone, Newark, N. J.
 King, G. W., Sperry Products, Inc., Hoboken, N. J.
 Kober, A. A., Wilputte Coke Oven Co., New York, N. Y.
 Landeck, J. H., Camp Evans, Belmar, N. J.
 Lankford, A. W., Jr., Federal Tel. & Radio Corp., Newark, N. J.
 Likos, T. A., Westinghouse Elec. Elev. Co., Jersey City, N. J.
 Long, A. S., Federal Tel. & Radio Corp., Newark, N. J.
 MacMillan, R., Standard Oil Development, Elizabeth, N. J.
 Mandel, M., Federal Tel. & Radio Corp., New York, N. Y.
 McAdams, B., Westinghouse Elec. Elev. Co., Jersey City, N. J.
 McCusker, R. W., Newark Signal Corps Inspection Zone, Newark, N. J.
 Mead, G. G., Gen. Elec. Co., New York, N. Y.
 Meinheit, C. E., Sperry Gyroscope Co., Lake Success, N. Y.
 Merrill, F. G., Bell Tel. Lab., New York, N. Y.
 Messa, M. F., W. E. & M. Co., Bloomfield, N. J.
 Messerschmidt, H. L., Bell Tel. Lab., New York, N. Y.
 Mexal, J. R. (Associate re-election), Pattengell Elec. Co., Brooklyn, N. Y.
 Meyer, R. H., American Gas & Elec. Serv. Corp., New York, N. Y.
 Miller, H. M., Federal Tel. & Radio Corp., Newark, N. J.
 Mraz, W. L., Bell Telephone Lab., New York, N. Y.
 Murray, C., Weston Elec. Inst., Newark, N. J.
 Neikirk, R. S., Federal Tel. & Radio Corp., Newark, N. J.
 O'Connor, J. P., Navy Yard, Brooklyn, N. Y.
 Otto, L. C., 32-36-47th Ave., Long Island City, N. Y.
 Owen, E. A., Hazeltine Electronics Corp., Little Neck, N. Y.
 Phillips, W. E., Jr., Federal Tel. & Radio Corp., Newark, N. J.
 Plevritis, G., Curtiss-Wright Corp., Caldwell, N. J.
 Pomerene, J. H., Hazeltine Electronics Corp., Little Neck, L. I., N. Y.
 Rabito, V. A., W. E. & M. Co., Bloomfield, N. J.
 Rogat, S., Heyman Co., New York, N. Y.

Ryan, L. M., Federal Tel. & Radio Corp., Newark, N. J.
 Scheerer, W. F., Consol. Edison Co., New York, N. Y.
 Shanser, K. S., Carbone Corp., Boonton, N. J.
 Simpson, M., Federal Tel. & Radio Lab., New York, N. Y.
 Singer, E., Federal Tel. & Radio Lab., New York, N. Y.
 Skeris, G. C., Wilputte Coke Oven Corp., New York, N. Y.
 Skobel, M., Ft. Monmouth Signal Lab., Little Silver, N. J.
 Steinhoff, R., W. E. & M. Co., Bloomfield, N. J.
 Van Fleet, C. D., Standard Oil Development Co., Elizabeth, N. J.
 Viney, H. E., Federal Tel. & Radio Lab., New York, N. Y.
 Wallenstein, J. P., Federal Tel. & Radio Corp., Newark, N. J.
 White, F. W., Bell Telephone Lab., New York, N. Y.
 Witzke, L. H., Curtiss Wright Corp., Caldwell, N. J.
 Young, K. W., Camp Evans Signal Lab., Belmar, Elizabeth, N. J.

4. SOUTHERN

Albright, W. G., Virginia Poly. Inst., Blacksburg, Va.
 Cormack, L. J., E. D. Badger & Sons Co., Baton Rouge, La.
 Drake, L. H., War Dept., Arlington, Va.
 Gill, H. W., 2nd Lt., Signal Corps, Headquarters Co. Reporting B. T. W. 503, Signal A. W. Regt., Drew Field, Tampa, Fla.
 Haymes, T. W., Jr., Gulf Shipbuilding Corp., Chickasaw, Ala.
 Hosmer, J. H., Allis-Chalmers Mfg. Co., Atlanta, Ga.
 Knox, J. W., 2nd Lt., Signal Corps, Knoxville, Tenn.
 Martin, R. A., 2nd Lt., Signal Corps, c/o Postmaster, New Orleans, La.
 Mills, M. H., U. S. Army, 1st Sea Search Attack Group (M), Langley Field, Va.
 Morrison, A. B., U. S. Army, Johnston, Fla.
 Petrou, N. V., 2nd Lt. Signal Corps, U. S. Army, Camp Murphy, Fla.
 Sheats, H. W., Jr., U. S. Naval Reserve, Charlotte, N. C.
 Stivers, R. M., Tenn. Valley Authority, Chattanooga, Tenn.
 Weston, W. H., Jr., Louisville G. & E. Co., Louisville, Ky.

5. GREAT LAKES

Bradburn, C. T., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Burdick, L. D., The Austin Co., Midland, Mich.
 Burk, W. R., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Collett, A. T., Ind. Ser. Corp., Fort Wayne, Ind.
 Cooper, J. A., Wabash R. R. Co., Decatur, Ill.
 Cremer, C. F., Chicago Signal Corps Inspection Zone, Kokomo, Ind.
 Dobbie, C. B., R. C. A. Victor Division, Indianapolis, Ind.
 French, A. D., Gen. Elec. Co., Kokomo, Ind.
 Gomborg, H. J., Univ. of Michigan, Ann Arbor, Mich.
 Kidd, C. S., Jr., Allen Bradley Co., Milwaukee, Wis.
 Kunkel, W. R. (Associate re-election), Commonwealth Edison Co., Chicago, Ill.
 Lisbakken, R. B., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 London, S., Gen. Elec. Co., Kokomo, Ind.
 McKinley, P. H., Allis-Chalmers Mfg. Co., West Allis, Wis.
 Messinger, H. P., Ill. Inst. Tech., Chicago, Ill.
 Mills, T. L., Gen. Elec. Co., Fort Wayne, Ind.
 Monro, C. R., R. C. A. Victor Division, Indianapolis, Ind.
 Owen, H. M., Gen. Elec. Co., Decatur, Ind.
 Petrucelli, V., Jr., Private, U. S. Army Air Forces, Chanute Field, Ill.
 Ptak, E. A., Electric Utilities, Chicago, Ill.
 Raab, H. P., Jr., R. C. A. Mfg. Co., Indianapolis, Ind.
 Rabogliatti, E. H., Gen. Elec. Co., Fort Wayne, Ind.
 Riggs, R. F., Allis-Chalmers Co., Milwaukee, Wis.
 Sauer, J. H., Mid-West Dynamometer & Engg. Co., Chicago, Ill.
 Scheibe, E. H., Univ. of Wis., Madison, Wis.
 Schmidt, J., Jr., Guardian Elec. Mfg. Co., Chicago, Ill.
 Schrot, E. H., Continental Radio & Television Corp., Chicago, Ill.
 Smith, E. D. (Associate re-election), Sargent & Lundy, Chicago, Ill.
 Soria, R. M., Ill. Inst. Tech., Chicago, Ill.
 Stahl, C. R., Gen. Elec. Co., Fort Wayne, Ind.
 Valentine, H. W., Jr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Vroman, L., Gen. Elec. Co., Detroit, Mich.
 Watkins, J. C., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Winglar, W., Allis-Chalmers Mfg. Co., West Allis, Wis.
 Wolfe, E., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
 Yurkanin, R. J., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

6. NORTH CENTRAL

Wilson, C. P., 110th Mtn. Signal Co., Camp Hale, Col.

7. SOUTH WEST

Batts, B. F., 2nd Lt. S. C. A. U. S., Kirkwood, Mo.
 Cearley, A. G., Curtiss-Wright Airplane Co., St. Louis, Mo.
 Dowell, K. P., Texas Technological College, Lubbock.
 Dunham, W. H., Jr., Radio Sta. KFBH, Wichita, Kans.
 Dunn, C. V., Evans Elec. Constr. Co., Kansas City, Mo.
 Franco, G. R., Rural Elec. Admin., St. Louis, Mo.
 Parker, E. R., Western Union Tel. Co., Dallas, Tex.
 Richardson, T. W. G., Jr., U. S. Naval Reserve, Ward Island, Corpus Christi, Tex.
 Smith, F. R., Gulf States Utilities Co., Beaumont, Tex.
 Smith, W. J., Rural Electr. Admin., St. Louis, Mo.

8. PACIFIC

Alexander, D. A., Barrett & Hilp, Hunters Point, Cal.
 Allen, F. W., North Amer. Aviation Co., Inglewood, Cal.
 Burke, B. R., Douglas Aircraft Co., El Segundo, Cal.
 Chamberlin, R. D., Consolidated Aircraft Corp., San Diego, Cal.
 Clark, J. S., Bethlehem Steel Co., San Francisco, Cal.
 Corcoran, E. G., Douglas Aircraft Co., Los Angeles, Cal.
 Felix, H. E., Douglas Aircraft Co., Santa Monica, Cal.
 Fowle, J. M., Joshua Hendy Iron Works, Sunnyvale, Cal.
 Gauden, G. S., Vega Airplane Co., Burbank, Cal.
 Gove, J. T., Douglas Aircraft Co., Los Angeles, Cal.
 Hill, C. R., U. S. Army Engr., San Francisco, Cal.
 Hudson, G. G., Univ. of Calif., Berkeley, Cal.
 Irion, A. D., So. Cal. Edison Co. Ltd., Alhambra, Cal.
 Johnson, R. E., McNeil Constr. Co., Las Vegas, Nev.
 Lacey, E., Douglas Aircraft Co., Santa Monica, Cal.
 Ledbetter, G. W., Douglas Aircraft Co., Santa Monica, Cal.
 Linn, J. S., Douglas Aircraft Co., Los Angeles, Cal.
 MacDonald, R. Q., Aluminum Co. of America, Torrance, Cal.
 Merrill, G. E., Douglas Aircraft Co., Santa Monica, Cal.
 Parker, K. L., Douglas Aircraft Co., Santa Monica, Cal.
 Porter, N. E., Permanente Metals Corp., Richmond, Cal.
 Friedgheit, J. H., Univ. of Calif., Berkeley, Cal.
 Rasmussen, D. V., Bethlehem Steel Co., San Francisco, Cal.
 Sorem, R. N., Columbia Steel Co., Pittsburg, Cal.
 Tesh, K. F., Douglas Aircraft Co., Santa Monica, Cal.

9. NORTH WEST

Hadley, A. D., Seattle-Tacoma Shipbuilding Corp., Tacoma, Wash.
 Huggins, W. H., Oregon State College, Corvallis, Ore.
 Jhntz, J. A., Jr., Radio Station KIDO, Boise, Idaho.
 Lowe, G. P., Boeing Aircraft Co., Seattle, Wash.
 Nelson, S. A., Seattle-Tacoma Shipbuilding Corp., Seattle, Wash.
 Pritchett, W. S., Oregon State College, Corvallis, Ore.
 Smith, E. H., Boeing Aircraft Co., Seattle, Wash.
 Wachter, R. V., Aluminum Co. of America, Vancouver, Wash.

10. CANADA

Buchanan, K. A., Otis-Fensom Elev. Co., Hamilton, Ont.
 Cox, G. M., Research Enterprises Ltd., Leaside, Ont.
 Duncan, A. J., B. C. Elec. Ry. Co., Vancouver, B. C.
 Gregory, R. R., Railway & Power Engg. Corp., Toronto, Ont.
 Johnson, D. G., Research Enterprises Ltd., Leaside, Ont.
 Kendall, O. K., National Res. Council, Ottawa, Can.
 MacPherson, C. A., Railway & Power Engg. Corp., Toronto, Ont.
 Morice, J. H., Jr., Can. Gen. Elec. Co., Peterborough, Ont.
 Ort, H. A., Packard Elec. Co., St. Catherine's, Ont.
 Quist, J. E., Canadian Gen. Elec. Co., Peterborough, Ont.
 Robinson, G. J., Canadian Gen. Elec. Co., Peterborough, Ont., Can.
 Rosenthal, A. L., Rogers Majestic Ltd., Toronto, Ont.

Elsewhere

Burgess, G. A., Dunoon & District Elec. Supply Co. Ltd., Dunoon, Argyll, Scotland.
 Casson, H. V., H. M. S. Offa. c/o G. P. O., London, Eng.
 Chapman, W. M., Westinghouse Elec. Co. of Brazil, Rio de Janeiro, Brazil.
 de Monchy, C. C., Paramaribo, Dutch Guiana.
 Evans, R. R., Jr., Signal Corps, U. S. Army, P. S. O., Quarry Heights, C. Z.
 Mandl, L. M., Electricity Meter Mfg. Co., Pty. Ltd., Waterloo, N. S. W., Australia.
 Pereira, D. A., Gen. Elec. S. A.-Rio de Janeiro, Brazil, S. A.
 Rosenberg, W., Aces Development Co., Manchester, Eng.
 Smrha, A. C., Westinghouse Elec. International Co., Medellin, Colombia, S. A.
 Stocker, J. C., Westinghouse Elec. International Co., Apartado 742, Panama, R. P.

Total to grade of Associate
 United States and Canada, 385
 Elsewhere, 10

OF CURRENT INTEREST

Ways of Conserving Critical Material to Aid Wartime Electrical Industry

The subcommittee on conservation of materials,* of the AIEE committee on co-operation with war agencies has assembled from information coming to its attention, examples of things that have been and are being done by the electrical industry to conserve critical materials. The subcommittee has obtained this information from many sources and, of course, has had no opportunity to investigate the various measures. Such of the items as have appeared in publications available to the industry as a whole are so credited. Others have been developed at recent meetings at which conservation was the principal theme. Still others have been brought to the attention of the subcommittee informally by engineers well-known in the electrical industry.

Some of these examples, it would seem, may be helpful in suggesting ways of making further savings in critical materials. Taken as a whole the list illustrates the great diversity of the conservation measures which have been and are being employed in the electrical industry to further the war effort.

Notes containing selected examples of this kind were sent to the several AIEE vice-presidents early in November for use in connection with meetings at which conservation of materials was to be the subject for discussion. Thinking such information might be of general interest also to the members of the Institute, the subcommittee has prepared the accompanying summary of the information sent to the vice-presidents and has supplemented it by examples that have come to its attention within recent weeks.

In order to be as helpful as practicable in assembling information along this line, the subcommittee would appreciate receiving from Institute members, information concerning other examples which they believe may be of possible interest to the industry as a whole. Information should be sent to J. W. Campbell, room 1722, 195 Broadway, New York, N. Y.

These conservation measures have been classified as follows:

- (A) Making the greatest possible use of what we have:
1. Increasing extent of use of existing facilities.
 2. Prolonging life.
 3. Reuse of recovered materials.

- (B) Limiting additions to and changes in facilities to those necessary for essential services.

* The personnel of the subcommittee on conservation of materials is as follows: H. M. MacDougal, chairman; J. W. Campbell; Thomas Spooner; P. L. Alger; R. W. Wilbraham; E. V. Sayles; A. E. Silver; M. S. Oldacre; and G. H. Doan.

- (C) Making minimum use of critical materials in necessary extensions:

1. Substitution of less critical materials for more critical materials.
2. Redesign to use less material.
3. Limiting additions to those required for immediate needs only.
4. Standardization.

- (D) Getting back into circulation materials which can be spared:

1. Clean up and dispose of junk.
2. Reduction of inventories.
3. Taking materials out of working facilities.

Making the Greatest Possible Use of What We Have

INCREASING USE OF EXISTING FACILITIES

Utilizing idle generating capacity by interconnection.

Assisting customers to make maximum use of their present electrical facilities and getting customers to schedule loads in off-peak periods. (*Edison Electric Institute Bulletin, April 1942, page 131.*)

Helping telephone customers to get more use out of their present service and equipment by shifting calls to off-peak hours, relocating telephones, shortening holding time on calls, improving practices of customers' operators and relieving them of extraneous duties. (*Contributed.*)

Loading transformers and voltage regulators to maximum capacity. (*AIEE Transactions, volume 61, 1942, September section, pages 669, 692.*)

Increasing system kilowatt capacity by reduction of generator kilovar requirements and provision of reactive capacity of other points in the system. (*Edison Electric Institute Bulletin, October 1942, page 363; Electrical World, June 27, 1942, page 90; AIEE Transactions, volume 61, 1942, May section, page 249.*)

Increasing loads on circuit breakers and switches by resurfacing contacts with silver alloy. (*Electrical World, October 17, 1942, page 65.*)

Conserving copper in secondary systems and saving transformer capacity by fusing and banking transformers. (*Electric Light and Power, June 1942, page 84.*)

Increasing capacity of transformers by use of supplemental cooling, packaged units, forced cooling, and addition of cooling tubes. (*AIEE technical paper 43-56, AIEE Transactions, volume 62, 1943; Electrical World, June 13, 1942, page 49; October 3, 1942, page 77; October 31, 1942, page 102.*)

Avoiding placing of new cables by increasing loads on existing cables. (*Edison Electric Institute Bulletin, November-December*

1942, page 405; *AIEE Transactions, volume 61, 1942, March section, page 107.*)

"Borrowing" spare and duplicate equipment for more active duty. (*Contributed.*)

Placing cross connecting terminals at judiciously selected points permits of working existing telephone cables to higher percentage of use. (*Contributed.*)

Meeting needs for submarine cable by having armoring placed on land cable drawn from stock. (*Contributed.*)

Making rearrangements of feeder and distribution plant, which under normal supply conditions are not warranted; raising allowable equipment loading; reducing or eliminating spare capacity; and permitting departure from standards of service. (*Contributed.*)

PROLONGING LIFE

Patching existing machines to avoid replacement. Parts patched include packing journals, vanes of water impellers, gear teeth, stoker crank shafts; valve stems and seats; turbine nozzle partitions; turbine runner. (*Electrical World, June 13, 1942, page 43; June 27, 1942, page 88; July 11, 1942, page 52; Edison Electric Institute Bulletin, February 1942, page 6.*)

Metalizing used to rebuild worn shafts, bearings. (*Society of Automotive Engineers paper, "Metal-Coating of Automotive Parts," H. S. Ingham, John E. Wakefield.*)

Putting stand-by equipment back into service. Example, a 45-year-old water-wheel generator put back into operation after 17 years as stand-by. (*Contributed.*)

Reversing windings on star connected hydrogenerator after fifteen years of service to obtain additional life. (*Electrical World, May 30, 1942, page 84.*)

Restoring worn felt heads on carriers, used in pneumatic tube system, to original diameter by subjecting them to high compression. (*Contributed.*)

Getting more life out of tools by instructing employees in proper care, improving repair practices, keeping rope dry, using tools longer before discarding. (*Mill and Factory, February 1942, pages 75, 168; Power, June 1942, page 79; Purchasing, March 1942, page 58.*)

Restoring cutting edges on reclaimed tools by chromium plating; edges are thus rebuilt and are generally better than unplated tool steel. Files are reclaimed by dipping in acid and giving them a thin chromium plating. (*Contributed.*)

Deferring for the duration, conversion of manual telephone central offices to dial operation, as replacement of existing equipment becomes desirable. (*The Northwestern Bell, December 1942, page 11.*)

Inspecting more frequently critical points of apparatus and equipment, and repairing small defects before they cause failure and serious damage. (*Contributed.*)

Providing instructions for repair of home appliances. (*Electrical World, November 28, 1942, page 96.*)

Leaving wires and cables in service even though, in the long run, it would be more economical to replace them with new cables. (Contributed.)

Exercising greater care in installation, operation, and maintenance of vital rubber products—wires, cables, belts, hose, gloves. Avoid exposure to excessive heat, keep free from oil, store in cool dark places, avoid mechanical abuse. Increases life from 10 to 200 per cent. (Power, June 1942, page 64.)

Tightening control of normal fire hazards which might cause destruction of stores of irreplaceable supplies and equipment. (Contributed.)

REUSE OF RECOVERED MATERIAL

Weatherproof wire is recovered for reuse by sorting and cutting out short bad sections; when braid is too bad for reuse, even though reimpregnated with compound, it is stripped off and wire is reused as bare conductor. (Salvage and Scrap Material Manual for the Utilities; Industrial Salvage Section, Conservation Division, War Production Board.)

Improved methods of sorting and storing permit recovery of short lengths of wire used for interconnecting equipment in telephone central offices. (Telephone Review, December 1942, page 10.)

Rubber covered wires and cables in communication systems are repaired in place whenever practicable; good sections of wire returned to the shop are spliced together and braid is reimpregnated using newly developed machinery. (Contributed.)

Damaged transformers are repaired by installing new parts such as core and coil assemblies. All reusable parts of such transformers are saved for assembly into good transformers. (Edison Electric Institute Conference on Reclamation and Salvage, February 1942, pages 3, 9, 12.)

Lead covered cables removed from plant are reused after being inspected and repaired; duct splices are used to join short lengths of power cables. (Edison Electric Institute Conference on Reclamation and Salvage, February 1942, page 15; March 1942, page 19.)

Practices developed for repairing recovered lightning arrestors, caps replaced, leads replaced or respliced. (Edison Electric Institute Conference on Reclamation and Salvage, February 1942, pages 9, 12.)

Recovered pole line hardware cleaned, straightened, spray galvanized, and painted. (Edison Electric Institute Conference on Reclamation and Salvage, February 1942, pages 12, 16; March 1942, page 11. Edison Electric Institute Bulletin, November 1941, page 459.)

Recovered porcelain insulators cleaned; chipped places revarnished. (Edison Electric Institute Conference on Reclamation and Salvage, February 1942, page 12; March 1942, page 11.)

Street lighting poles and fixtures repaired, broken poles welded, fixtures rebuilt, good parts reclaimed. (Edison Electric Institute Conference on Reclamation and Salvage, February 1942, pages 9, 17; March 1942, page 12.)

Solder is recovered from wiped joints in cables removed from plant; solder drip-

pings saved. Babbitt recovered from worn-out bearings. (Edison Electric Institute Conference on Reclamation and Salvage, March 1942, pages 11, 14, 21.)

Obsolete switches converted to modern type using odds and ends of old bus bars. (Edison Electric Institute Conference on Reclamation and Salvage, February 1942, page 9.)

Valves and pipe fittings repaired, re-threaded, reseated, cracks welded, new discs provided. (Edison Electric Institute Conference on Reclamation and Salvage, February 1942, page 10; March 1942, page 21.)

Telephone switchboards removed from one location are reused in other localities; are sometimes converted from one type of switchboard to another. (The Northwestern Bell, December 1942, page 11.)

Practices and apparatus developed to avoid damaging telephone line wire during removal. After removal, all good sections are carefully selected and are spliced together with rolled or crimped sleeves. (Contributed.)

Old style telephone sets held for emergency are being used to avoid current manufacture of new sets. (Contributed.)

Old crossarms are used to make secondary racks. (Electrical World, November 26, 1942, page 88.)

How Utilities Are Solving Operating Problems Arising Out of the War. A symposium of 142 actual cases. (Electrical World, May 30, 1942.)

Industrial Production's Electrical Aids. (Electrical World, December 12, 1942, page 66.)

Limiting Facility Additions and Changes to Those Necessary

In addition to the savings that the power and communication companies have been able to effect voluntarily, substantial savings have also been effected as a result of certain WPB orders which, generally, limit construction to that necessary for the war effort except in cases where the necessary facilities are already available.

The WPB orders also provide the utilities with the preference ratings for the purchase of the necessary materials for maintenance repair, operating supplies, and for minor construction jobs, such as permissible service connections.

Minimum Use of Critical Materials in Necessary Extensions

SUBSTITUTION OF LESS CRITICAL MATERIALS

Substitutions for Aluminum

Aluminum alloy castings, aluminum name plates, and cases for electrical instruments replaced by parts fabricated of wood, steel, plastics. (Contributed.)

Aluminum in pole insignia, paints, name plates, and bases and housings for apparatus employed in telegraph operations conserved by substitution of more plentiful materials. (Contributed.)

With the exception of condenser foil, substitutions have eliminated practically all requirements for aluminum among the

telephone companies; plastics replace aluminum alloy castings for housings of "combined" telephone set. (Contributed.)

Substitutions for Copper

Copper for nonconductor purposes replaced by steel, malleable iron, terne-plate, brass, bronze, and zinc; problem of protecting steel against corrosion. (General Electric Review, July 1942, pages 407-14.)

Bus bars made from steel pipe and structural shapes; comparison of shapes, tests of current capacities, effect of painting and slotting, problem of heat transfer. (Electrical World, April 18, 1942, pages 67-8; June 27, 1942, pages 67-8; November 28, 1942, page 49.)

Galvanized steel wire and strand used for power conductors; State Railroad Commission provisions permitting restricted use; instructions prepared covering use. (Electrical World, June 6, 1942, page 7; July 18, 1942, page 7; September 19, 1942, pages 50-4; November 28, 1942, page 80.)

Roof-flashings, rain conductors, and water pipe of ferrous metals replacing copper in building construction. (Contributed.)

Steel wire replaces copper in exchange telephone service and, where practicable, in toll lines; copper-clad steel used extensively in toll construction and in drop wire. (Contributed.)

Copper-clad steel in both the wire form and the more recently available strip form is finding a number of important new applications. For instance, copper-clad steel is replacing copper blades and jaws for certain types of knife switches in the smaller sizes; copper-clad steel used for conductors of cable for general control wiring in electrical manufacture; 7/16-inch copper-clad steel strand substituted for 2/0 American wire gauge copper conductors on a 115-kv line. (Contributed.)

42-inch salt water circulating pump runner made from cast iron instead of bronze. (Electrical West, November 1942, page 41.)

Silver replaces copper for bus bars of government-owned plants. (WPB Release 1957, October 2, 1942.)

Brass-coated steel replaces brass in lamp bulb bases; nickel-plated iron instead of pure nickel wire, tin content of solder and size of solder tip of lamp bases reduced. (WPB Release 1316, June 8, 1942.)

Zinc coated steel screws and nuts substituted for brass hardware for contact screws in ratings up to 30 amperes. (Contributed.)

Plated steel has been substituted for brass in the manufacture of inserts used in molded parts. (Contributed.)

Substitutions for Steel

Wood substituted for structural steel shapes in substation construction. (Electrical World, April 18, 1942, page 100; May 30, 1942, page 91. Electrical West, December 1942, page 47. Edison Electric Institute Bulletin, November 1941, pages 459-61.)

Wood replacing steel in uprights supporting cables, relays, and repeaters, in telephone offices; designed so that wood can be replaced with steel later. (Contributed.)

Hardware changed from steel to wood;

examples: pins and pin brackets, braces, guy guards, street and boulevard poles, racks, transformer platforms, anchors, and fixtures. (*Edison Electric Institute Bulletin*, November 1941, pages 459-61; February 1942, pages 48, 52.)

Wood replaces 95 per cent of steel used in telephone booths. (*Contributed*.)

Reinforced concrete replaces structural steel in telephone buildings. (*Contributed*.)

Plywood and transite substituted for sheet steel for fan housings, air ducts, and perforated transite for perforated sheet steel in acoustic ceilings. (*Contributed*.)

Industrial lighting reflectors manufactured of wood fiberboard, laminated-paper plastic, molded cement-asbestos board and asbestos in laminated sheet instead of steel. (*Electrical World*, October 31, 1942, page 74.)

Cast iron or cast steel substituted in some cases for steel drop forgings for crankshafts, connecting rods, and similar parts. (*Contributed*.)

Merit of precast concrete cones instead of steel anchors for overhead electric lines demonstrated by 12 year's service in western utility. (*Electric Light and Power*, December 1942, page 58.)

Development of national emergency (lean-alloy) steels emphasizing mechanical and physical properties rather than temperature or corrosion resistance conserves vital elements for use where high alloy steels are essential. (*Chemical and Metallurgical Engineering*, September 1942, page 90; *Metal Progress*, October 1942.)

Wood, instead of steel, used for cable boxes, meter boxes, and for housing protectors and telephones located out-of-doors. (*Contributed*.)

Cement-asbestos, plastics, glass, and concrete encased glass or terra cotta as substitutes for steel and iron in the manufacture of pipe for various uses. (*Chemical and Metallurgical Engineering*, September 1942, page 90.)

Paper laminated with Vinsol resin made into pipe suitable for electrical conduit or for temporary low-pressure piping as a substitute for steel. (*Chemical and Metallurgical Engineering*, December 1942, page 104.)

Substitutions for Tin

Reduction of tin content in babbitts, solders, and metals for hot-dipping connections; silver brazing for heavy joints instead of 100 per cent tin. (*General Electric Review*, July 1942.)

Tin content of wiping solder substantially reduced by substitution of lead and small proportion of antimony; very substantial reductions also made in tin content of resin core solder. (*Contributed*.)

Silicon bronze replaces tin bronze for higher resistance induction motor bars. (*Contributed*.)

Brass flashed lead coating replaces tin coating on conductors of rubber insulated telephone wire. (*Contributed*.)

Addition of 0.06 per cent copper permits power cable manufacturer to eliminate the 2 per cent tin formerly used in cable sheathing. (*Contributed*.)

Glass and fiber have been substituted for tinned-steel containers for holding solvents, oils, and varnishes. (*Contributed*.)

Miscellaneous Substitutions

Lead coating replaces galvanizing on many items of pole line hardware; manufacturing equipment formerly used for zinc galvanizing adapted for lead dipping. (*Contributed*.)

Rust-inhibiting primer and paint used in place of galvanizing on certain items of pole line hardware. (*Mechanical Engineering*, January 1942, pages 30-1.)

Plastics replace rubber as insulation for flexible conduit used in planes, tanks, and boats. (*General Electric Review*, October 1942, page 595.)

Paper, varnished fabric, asbestos, and glass replace mica in the manufacture of certain communication and electrical equipment. (*Contributed*.)

Bushings and insulation spacers in communication equipment changed from rubber to wood, fiber, or plastic. (*Contributed*.)

Special silicon iron is being substituted to a considerable extent for nickel iron alloys used for laminations. (*Contributed*.)

Nickel saved by the substitution of high strength carbon steel for nickel-bearing alloy steels in the manufacture of electrical apparatus. (*Contributed*.)

Electro zinc coatings replace cadmium finishes for many applications. (*Contributed*.)

Glass replaces critical metals: glass impellers and plates for centrifugal pumps, glass sole plates for electric irons, glass plumbing for homes and industry. (*Contributed*.)

Copper, tin, and rubber saved by reduction in wire gauges, substitution of tin alloy for pure tin coatings on wires, and reduction of crude rubber content or substitution of synthetic asphalt and wax in insulating compounds. (*Contributed*.)

Glass compositions replace scarce sapphires used as pivot bearings in sensitive electrical instruments. (*Chemical Industries*, July 1942, page 38.)

Storage battery jars made from vitrified ceramic instead of rubber. (*Fortnightly Telephone Engineer*, January 1, 1943, page 16.)

Pentachlorophenol replaces creosote for full length nonpressure treatment of western red cedar poles. (*Electrical World*, November 28, 1942, page 94.)

Concrete, clay, and gypsum products urged as substitutes for lumber to ease shortage. (*WPB release* 1930, September 29, 1942.)

Substitutions in materials and changes in practices covering 56 items representative of electrical utility operation. (*Electrical World*, October 17, 1942, page 63.)

Tin requirements reduced by substitutions in solders, babbitts, and bronzes; steel and iron substituted for aluminum, brass, and bronze; masonite for steel; silver or zinc replacing tin and cadmium plating; carbon for nickel steel; fiber, bakelite, and other plastics used for name plates; bakelite, plastics, and varnished and glass fiber cloth replace shellac, mica, and rubber as insulation; conservation of materials and tools on hand. (*The Canadian Purchaser*, December 1942.)

Wood fiber products substitute for hard rubber, textiles for soft rubber in cords,

lower grades and other alloys for grade A brass, plywood and steel for aluminum, and wood for steel in telephone plant. (*Contributed*.)

REDESIGN TO USE LESS MATERIAL

Construction of 33-kv line without cross-arms or associated pole line hardware. (*Electrical World*, May 30, 1942, page 91.)

Crossarm braces and associated fastenings saved by horizontal V type of transmission crossarm construction. (*Electrical World*, May 30, 1942, page 92.)

1,000-kva substation constructed at one-fifth cost and one-fifth space requirements of 600-kva station by simplification of protection devices. (*Electrical World*, May 30, 1942, page 91.)

Design of substations modified to meet wartime necessities: wood substituted for steel; lighter and more flexible structures used without undue sacrifice of safety; duplicate bus arrangements eliminated where practicable; fuses substituted for high side breakers; use of three-phase transformers offers economies compared to three single-phase units. (*AIEE Transactions*, volume 61, 1942, March section, pages 177-22.)

Opportunities for saving of material in building wiring presented through use of CNX cable and careful planning of wiring layout. (*Edison Electric Institute Bulletin*, November 1941, page 437; April 1942, page 134.)

Banking secondaries permits use of smaller wire sizes and fewer secondary transformers. (*Electric Light and Power*, June 1942, page 84.)

Load-center distribution system for industrial plants effects savings in critical materials at lower cost. (*AIEE Transactions*, volume 61, 1942, May section, page 272.)

400 tons of copper saved in construction of magnesium plant by careful design of bus bars and ordering feeder cable in exact lengths. (*Electrical West*, October 1942, page 48.)

A supplementary switchboard, consisting of a small table-mounted cabinet has been designed to handle outgoing long distance telephone calls. Requires more operators but saves manufacturing capacity and materials. (*Contributed*.)

Window-type instrument transformers offer savings in copper in manufacture and installation as compared to the bar type. (*Contributed*.)

Greater cooling efficiency through forced circulation of transformer oil permits reduction in size and weight of transformer by one-third to one-half for given capacity with corresponding reduction in materials. (*Westinghouse Engineer*, August 1942, page 97.)

Efforts directed toward reduction of waste material and cutting number of rejections in manufacturing plants yield big dividends. (*WPB Release* 1847, September 13, 1942.)

"Victory joint" saves upward of 60 per cent of tin formerly required for wiped joints. (*New England Telephone and Telegraph Company*, "Telephone Topics," March 1942, page 7; *Telephone Engineer*, April 15, 1942, page 31; *Electrical World*, August 22, 1942, pages 48-50.)

Wrapping replaces solder-wiped sleeve joint for cable splices located where they are unlikely to be affected by moisture, as in buildings. (Contributed.)

Tin in solder saved by brazing together the wire ends of motors and generators; pressure type connection largely eliminates need for solder in medium-size wire and cable connections to terminals. (Contributed.)

Improved design of telephone loading coils ("lumped" impedance) reduces material required by 50 per cent in exchange coils and by 80 per cent in toll coils. (Contributed.)

Telephone central office apparatus safely supported on steel members of reduced section. (Contributed.)

"Use Next Smaller Rating" proposed as slogan in campaign to save 25 per cent material and labor in motor production. (Electrical World, August 1, 1942, page 18.)

High-frequency induction heating of tinned sheet steel after leaving electrolytic plating tanks saves two-thirds of the tin formerly used in dipping process. (Electrical Engineering, volume 61, December 1942, page 673.)

"Overmotoring"—its adverse effects on motor production capacity and on the design of the associated transformer and distribution system. (General Electric Review, October 1942, page 555.)

Departure from standard design limits saves ten per cent of the copper required for a three-conductor 66-kv underground cable line plus accompanying savings in associated items. (Contributed.)

Increasing load ratings of overhead wires, if practicable, where temperature is the controlling factor. (Contributed.)

Line wire spliced using single tube compression type sleeves, instead of double tube twisted sleeves, to save copper. (Contributed.)

Shellac has been eliminated in certain types of condenser bushings by using a new construction and oil impregnation. (Contributed.)

Powder metallurgy offers opportunity for creation of alloys with special properties and cheap and efficient mass production of machine parts not requiring high strength. (Electrical Engineering, volume 61, September 1942, page 468.)

Ignitron rectifier units save space and weight over rotary converters of equivalent capacity. (Electric Light and Power, December 1942, page 44.)

Shortage of critical materials used in fuse link manufacture emphasizes need to consider measures to reduce or eliminate transformer fuse operation. (Electrical World, December 12, 1942, page 90.)

Copper bus saved by paralleling current transformers when station load is increased. (Electrical World, December 12, 1942, page 98.)

Interim amendments to National Electrical Code allow savings in material through liberalization of present code standards. (Supplement to 1940 National Electrical Code, September 1, 1942.)

Improved arc-welding technique yields stronger weld while using only a fraction

of the welding electrode previously required. (Power, July 1942, page 69.)

ADDITION OF PLANT FOR IMMEDIATE NEEDS ONLY

Power station extensions limited to facilities required for immediate war necessities, no provision made for growth or non-essential needs. This procedure, in the long run, will make plants cost more but saves materials now. (Contributed.)

Telephone cables designed for periods of three years or less instead of more economical periods, effect large savings of copper. (Contributed.)

Unit substations, which may be installed quickly and moved quickly to new locations, recommended as means of increasing capacity for war loads economically while offering maximum salvage possibilities after serving their purpose. (AIEE Transactions, volume 61, 1942, March section, pages 117-22; Electrical World, November 16, 1940, page 60.)

STANDARDIZATION AND SIMPLIFICATION

At the request of various governmental departments and trade associations the American Standards Association has undertaken standardization of numerous items under the War Standards Procedure. These include:

Protective Lighting for Industrial Properties.
Electrical Indicating Instruments.
Machine Tool Electrical Standards.
Military Radio Equipment and Parts.
Packages for Electronic Tubes.
Fixed Mica-Dielectric Capacitors.
Quality Control.
Replacement Parts for Civilian Radio.
Threading of General Purpose Nuts and Bolts.

In addition, the Simplification Branch of WPB has issued conservation orders simplifying and standardizing some 60 odd items, and orders affecting upward of 150 additional items are in process of preparation (Business Week, November 28, 1942, page 15.). Some of the items included are:

Hand Tools.	Instruments, Valves, and
Scales and Balances.	Regulators.
Batteries, Automotive	Ladders.
Storage.	Motor Brushes.
Batteries, Dry Cell.	Motors, Electric.
Cement, Portland.	Portable Electric Tools
Seamless Mechanical	Pumps, Water.
Tubing.	Taps and Dies.
Soldering Irons, Electric.	Valves.
Steel Wire Rope.	Welding Machines.
Structural Steel Shapes.	Wiring Devices, Elec-
Switches, Electric.	trical.
Incandescent, Fluores-	Shovels, Spades, Scoops,
cent, and other Elec-	Telegraph Spoons.
tric Discharge Lamps.	Valves.
Lighting Fixtures, Fluores-	X-Ray Equipment.
cent.	Aluminum, Rods, Sheets,
Pipe Fittings.	and Tubing.
Plywood, Douglas Fir.	Auger Bits.
Saws, Wood.	Builders Hardware.
Engines, Small Gasoline.	Carbon Steel Plates.
Files and Rasps.	Electrical Control Equip-
Heat Exchanges.	ment.
Fittings, Pipe, Steel.	

The standards committee of the AIEE is working also on wartime standardization, particularly in producing standard guides to permit maximum use to be made of electrical equipment under various conditions. Further information concerning the work of this committee and a list of the guides

that are already available are contained in the article "AIEE Standards Being Revised to Meet Wartime Needs" appearing on pages 114-15 of the March 1943 issue of Electrical Engineering.

Getting Unneeded Materials Back Into Circulation

CLEAN UP AND DISPOSE OF JUNK

Changes in methods of handling alloy scrap, old parts, and idle equipment speed manufacture's surplus materials into active use. (Edison Electric Institute Conference on Reclamation and Salvage, March 16, 1942, page 15; Automotive Industries, October 1942, page 11.)

Construction gangs salvage scraps of line wire and tie wires found along lines. (Edison Electric Institute Conference on Reclamation and Salvage, March 16, 1942, page 7.)

Idle equipment checked for disposition as scrap. (Edison Electric Institute Conference on Reclamation and Salvage, March 16, 1942, page 7.)

Committees judge idle apparatus as potential scrap or for sale to vendors for reuse. (Edison Electric Institute Conference on Reclamation and Salvage, February 4, 1942, page 7.)

Former World War test generator goes to scrap pile. (Electrical World, December 12, 1942, page 136.)

Recovered scrap accounts for 7 per cent to 50 per cent of the total new supply of zinc, tin, nickel, copper, and steel. (WPB Release X-0833, July 13, 1942; Steel Facts, December 1942, page 8.)

Unused pneumatic tubing scrapped by one utility yields 100,000 pounds of copper. (Contributed.)

Iron salvaged from old dump of cast iron borings. (Automotive and Aviation Industries, October 1942, page 54.)

Recovery processes applied to ash from refuse and rubbish burned in two process steam boilers and to waste lubricant from wire drawing yield worth-while quantities of metal in electrical manufacturing plant. (General Electric Review, October 1942, page 592.)

By pulling out the core alone, copper is salvaged from telephone cables which are so firmly lodged in ducts that the cable cannot be withdrawn intact. (Contributed.)

Collecting scrap is a continuing process (Electric Light and Power, August 1942, page 82.)

Engineering practices can help to get the maximum value from the nation's metal supply by specifying materials with minimum tendency to produce scrap, selecting fabricating operations that produce least waste in forming, ordering parts in finished form, limiting quality and precision to minimum necessary. (Metals and Alloys, August 1942, page 3.)

Survey of lines in service by one utility results in removal of 45,000 pounds of steel-cored aluminum wire for disposal as scrap. (Edison Electric Institute Sectional Conference, February 4, 1942, page 4.) Comparable types of surveys by the telephone companies have resulted in recovery of electrolysis drainage wires no longer required, as

well as other items containing critical materials. (Contributed.)

Nickel and other critical materials used in alloying steel are "mined" from steel scrap. (*Steel Facts*, December 1942, page 8.)

Slide film, "Get in the Scrap," prepared by Industrial Salvage Section of WPB dramatizes things that may be done by industrial concerns to facilitate collection of scrap. (For details on film consult regional WPB office.)

REDUCTION OF INVENTORIES

Utilities release material and equipment in excess of their own immediate needs in order to assist other companies in meeting their essential requirements. (Contributed.)

Periodic inventory checks of frequency of use of idle stocks by eastern utility assist in moving material toward useful channels. (*Edison Electric Institute Sectional Conference*, February 4, 1942, page 11.)

Equipment carried for possible reuse checked to determine advisability of putting it into scrap. (*Edison Electric Institute Sectional Conference*, March 16, 1942, page 7.)

Salvage engineer reviews removal work orders and arranges in advance for prompt release of reusable equipment to second-hand market. (*Edison Electric Institute Sectional Conference*, March 16, 1942, pages 13-16.)

Utilities classify inactive cable into groupings which, in addition to showing cable to be junked, furnish an inventory of cable needed for emergency use or suitable for removal elsewhere. (*Electrical World*, October 24, 1942, page 4.)

Transfers of copper from idle and excess inventories enable hundreds of war plants to maintain schedules. (WPB Release 1826, September 9, 1942.)

TAKING MATERIALS FROM WORKING PLANT

Multigrounding of primary neutrals and interconnection of arrester grounds with secondary neutrals enable midwest utility to recover considerable amounts of wire. (*Electrical World*, May 30, 1942, page 82.)

Rearrangement of several substations on a 220-kv system releases considerable amounts of equipment to meet expansion at other points. (*Electrical World*, August 8, 1942, page 90.)

Replacement of telephone copper line wire with smaller gauge conductors in cable or by substitution of carrier channels is effecting large net savings in copper. (Contributed.)

The addition of a few cable terminals or a short section of cable may result in the release of considerable quantities of telephone drop wire which can be reused. (Contributed.)

Circuit breakers removed from existing locations to meet needs of system expansion; those removed chosen by study of the system, its facilities, and historical reasons behind installation of each section. Existing breakers can sometimes be replaced by air-breaks. (*Electric Light and Power*, January 1943, page 69; *Electrical World*, January 9, 1943, page 43.)

Science Scholarships Awarded by Westinghouse Company

Miss Gloria Lauer, Ames, Iowa, and Raymond Schiff, New Rochelle, N. Y., both high-school seniors, received recently the highest awards of four-year Westinghouse science grand scholarships worth



\$2,400 each in the annual science talent search sponsored by Science Service and the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. Other Westinghouse science scholarship awards amounting to a total of \$6,200 were made to 38 high-school seniors throughout the United States.

Radio Communication Equipment Wanted by Signal Corps

Radio amateurs have been requested to sell their short-wave communication equipment to the Signal Corps, Army Services of Supply. This equipment is needed both for training purposes and operational use, the War Department has announced.

The radio communication equipment needed consists of transmitters, ranging in power from 25 watts to 450 watts and covering various bands in the short-wave range, as well as the corresponding types of receivers and such radio components as capacitors, resistors, and installation material. Especially desired are audio-frequency and radio-frequency signal generators and oscilloscopes, precision a-c and d-c voltmeters, ammeters and milliammeters, and other equipment for testing.

Used equipment will be purchased if it is in perfect operating condition or if it can be restored readily to such condition. The price paid for each item will be set by a Signal Corps inspector. Persons in possession of the desired equipment who wish to sell it for the use of the Army are invited to send a brief description, including the name of the manufacturer and model type, to Captain James C. Short, at the Philadelphia Signal Corps Procurement District, 5000 Wissahickon Avenue, Philadelphia, Pa.

The complete list of the desired equipment follows:

Transmitters—Hallicrafter and Collins.

Receivers—Hallicrafter, National, RME, Hammarlund, and Howard.

Meters—Weston.

Capacitors—mica and paper.

Oscilloscopes—audio signal generators and radio-frequency Signal Generators.

Electrical Engineers Needed by Signal Corps

The United States Army Signal Corps still has a need for electrical engineers as commissioned officers, particularly engineers qualified in the fields of radio and electronics because of education and experience.

While the appointment of officers from civilian life has been considerably reduced under recent policies of the Secretary of War, applications are urgently desired from men qualified as radio engineers and electronic physicists. These occupations, under present policy, have been classified as scarce categories, and men in this group between the ages of 22 and 45 are eligible for commission. For other branches of electrical engineering, men may be commissioned if they have reached the age of 35.

Some of these men may be assigned immediately to Army duties which they are qualified to perform by virtue of their civilian experience. Others may be assigned to special officer training courses and technical training in electronics and high frequency radio, in order to fill vital positions in specialized Signal Corps activities.

Persons interested in commissioned service with the Army, in accordance with the foregoing program, should apply to the local Officer Procurement District office nearest to their homes. They should not apply to the Chief Signal Officer, since the procurement function has been taken over by the Officer Procurement Service.

War Training in Communications Aided by Bell Laboratories

The 22d class of the War Training School conducted by Bell Telephone Laboratories, New York, N. Y., completed its course February 18, 1943, and left for further training or for duty as civilian employees of the United States Army. This school has now trained 1,300 men in the operation of communications developed by Bell Laboratories. Its "faculty" is composed entirely of 36 members of the Bell Laboratories technical staff. So new is the information to be imparted that the "faculty" has already had to write nearly 2,000 pages of textbook material.

The school, which is under the direction of R. K. Honaman (F '36), was organized as the result of a request of the Signal Corps, and the first class began on April 27, 1942.

Instruction now goes on eight hours a day and six days a week, and students from the Navy and other branches of the Army are included. Registration for the school is handled entirely by the armed forces. Applications through the Bell Laboratories cannot be considered.

OTHER SOCIETIES •

Symposium on Dielectrics to Be Held by Electrochemical Society

A symposium on the dielectric problems involved in the development and maintenance of insulating materials is to be held under the auspices of the Electrochemical Society April 9-10, 1943, at Pittsburgh, Pa. This symposium, which AIEE members are invited to attend, will be under the direction of F. M. Clark (A '24), chairman of the committee on dielectrics of the Electrochemical Society and technical assistant engineer, laboratory, General Electric Company, Pittsfield, Mass. The following papers will be presented:

ELECTRICAL PROPERTIES OF POLYVINYL ACETATE. T. W. Dakin, Westinghouse Electric and Manufacturing Company

CHEMICAL CHANGES AFFECTING THE STABILITY OF CELLULOSE INSULATION. F. M. Clark, General Electric Company

HIGH TITANIA DIELECTRICS. E. Wainer, Titanium Alloy Manufacturing Company

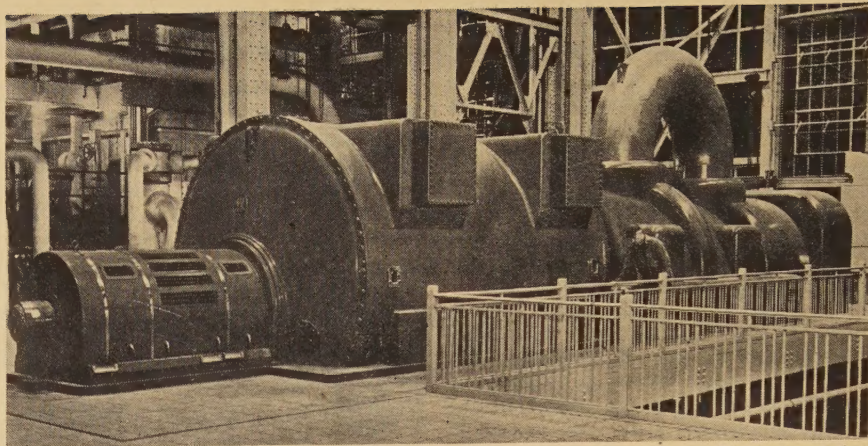
PRESTITE, IMPROVED METHOD FOR MOLDING ELECTRICAL PORCELAIN. E. H. Fischer, Westinghouse Electric and Manufacturing Company

ALUMINUM ELECTROLYTIC CONDENSERS. P. Robinson, J. Burnham, Sprague Specialties Company

CATHODIC CORROSION OF CABLE SHEATHS. Herman Halperin, Commonwealth Edison Company

A. A. Potter Receives 1943 Washington Award

Audrey A. Potter, dean of engineering at Purdue University, Lafayette, Ind., and chairman of the National Advisory Com-



Westinghouse photo

This 45,000-kw, 3,600-rpm turbine generator was installed recently by the Connecticut Light and Power Company; the 50,000-kva generator is hydrogen cooled

mittee on Engineering and War Training, has been awarded the Washington Award for 1943 for "distinguished leadership in engineering education and research, and patriotic service in mobilizing technical knowledge for victory in war and peace." The presentation was made on February 24, 1943, at the Union League Club, Chicago, Ill.

The award, established in 1916, is made annually by the Washington Award Commission, which is composed of nine representatives of the Western Society of Engineers and two each of the AIEE, the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the American Institute of Mining and Metallurgical Engineers. The recipient must be an engineer "whose work in some special instance or whose services in general have been noteworthy for their merit in promoting the public good."

Protective Footwear Standards Developed by ASA

The war committee on protective occupational footwear of the American Standards Association has prepared drafts of proposed standards on conductive work shoes for men and electrical hazard shoes for men. These footwear specifications are being formulated with the idea of promoting increased protection for manpower in war industries involving electrical safety hazards. Proposals to develop specifications for women's conductive shoes are being studied by the committee. Recently the American War Standard for Men's Safety-Toe Work Shoes was completed.

Information pertaining to protective footwear standards and proposed standards can be obtained from the American Standards Association, 29 West 39th Street, New York, N. Y.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are

expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without letter, the other lettered. Captions should be supplied for all illustrations.

Future Meetings of Other Societies

American Chemical Society. Spring convention, April 12-16, 1943, Detroit, Mich.

American Society of Mechanical Engineers. Spring meeting, April 26-28, 1943, Davenport, Iowa; semi-annual meeting, June 14-16, 1943, Los Angeles, Calif.

American Society for Testing Materials. Annual meeting, June 28-July 2, 1943, Pittsburgh, Pa.

Association of Iron and Steel Engineers. Spring conference, May 10, 1943, Pittsburgh, Pa.

Electrochemical Society. April 7-10, 1943, Pittsburgh, Pa.

Midwest Power Conference. Annual meeting, April 9-10, 1943, Chicago, Ill.

National Electrical Manufacturers Association. Spring meeting, April 20-23, 1943, Chicago, Ill.

National Fire Protection Association. May 10-14, 1943, Chicago, Ill.

Inventions, Patents, and the Engineer

To the Editor:

The article, "Inventions, Patents, and the Engineer," by W. E. Crawford in the January 1943 issue of *Electrical Engineering*, pages 10-16, should be carefully read and analyzed by every engineer or other person who has any desire to form an opinion as to the merits and demerits of the United States patent system. Fortunately, the special interests of the engineer do not

conflict in any way with the interests of the public in this respect. The engineer has, however, a greater interest in the matter than the average citizen because of a closer contact with inventions.

W. E. Crawford is obviously a man who can draw proper conclusion from an extensive experience. It is of the utmost importance that other engineers think as clearly on this and other important questions that are now before us. Engineers are particularly dependent upon the patent system for continued employment, and particularly for the opportunity to do what

they most desire to do, namely, to produce new and improved processes and apparatus. Obviously, if the new things can be duplicated by competitors as fast as they are produced, it is going to be hard to induce anyone to finance their development, and abolishment or further curtailment of the patent system means less employment for engineers and, what is worse, less opportunity for the engineers to use their creative powers. Mere engineering which consists in applying old rules to the production or operation of old things is not much fun, and an engineer who spends his life in merely filling out calculation sheets misses the thrill of seeing something, which he helped to create, operate successfully. A large part of technical education in the United States is directed to fitting engineers to design new things, but few of us, even now, ever get a chance to do much original design work. Much of our time is spent on details of design or revamping of old designs, which involves very little creative thinking.

If the patent system is abolished or rendered ineffective by socialistic changes, not only will the total employment of engineers be reduced, but present designs will be frozen and creative work by engineers greatly reduced. Obviously, if new designs become available to everyone as fast as they are produced, there is not much incentive for anyone to do the engineering and development necessary to produce them. We can admit that the desire for profit is low and ignoble, but the fact remains that it is a force that has produced results up to date, and no one has yet demonstrated to my satisfaction that anything can take its place as an effective driving force.

It is really essential that those who have been taught to think clearly use their heads during the next few years and thus help guide and direct the great mass of our people who cannot do so. The world is groping for a new and better social order, and we should all work for it, but we should try to be sure that it will be better and not just new. We should be equally careful, as Mr. Crawford points out, that we do not follow rule 816 and condemn changes just because they are new.

The question of changes in the patent laws is just one phase of the broader question of what sort of a government we really desire. Absolute freedom is, of course, impractical, although some Indian tribes are able to approximate it closely, thanks to a beneficent government. Most of us give up our freedom for 40 or more hours a week during which we work for and under the direction of a master. We cannot obtain our freedom by hanging the boss, as our serfdom is imposed by our necessity to eat, sleep, raise children, and wear clothes, and our self-imposed necessities, like smoking cigarettes and drinking hard liquor. We accept restraint when it is profitable for us to do so, and industry accepts the restraint of patents for the same reason.

The socialists believe that it would be individually profitable to us to give up more of our freedom to the state. Perhaps

this is true, but freedoms lost are hard to regain, and before we surrender any freedom, we had better be sure that we get an adequate price for it. The right to own and to be protected by the state in the ownership of private property is such a freedom. Any right of ownership is merely a right of exclusion. A boy's ownership of a bicycle is merely a right of exclusion, as, if he could find a bicycle he would not need a license to ride it. Whoever owns the bicycle merely has a right to prevent others from riding it, and if bicycles were common property, anyone who could find one could ride it without interference. An inventor has a moral right to his invention, since he created it; that is, he has a moral right to prevent others from using it. We do not, however, recognize this moral right, but grant a rather limited legal right under a patent because we think, quite correctly, that by so granting patents we promote the common good. If, as socialism teaches, private property is a public wrong and we should not be allowed to exclude others from the use of things, of course, patents are wrong. In the final analysis, the decision depends on whether you think democratically or socialistically, whether you believe in individual rights or an all dominant public right. It is, however, a virtue of the American system that such questions are decided by the majority, and if a majority of the people want more socialism, the rest of us must submit. The socialists have made great gains during the last ten years, and this movement to abolish patents or modify the patent and other laws as to private property is purely socialistic.

I agree with Mr. Crawford that the attempts of the socialists to abolish or impair seriously the effectiveness of the patent system are most unwise. I hope I am not too much influenced by the fact that those who propose these changes obviously have had little experience with the system and only a very superficial knowledge of how it operates. Mr. Crawford seems to blame Thurman Arnold for his hostility to the patent system. Thurman Arnold is, however, an Assistant Attorney General of the United States, and whatever his socialistic bias, if he has one, the fact remains that he undoubtedly has been trying sincerely to do his duty. Even if we consider him an advocate of a new social order, which we do not desire, we should still try to assist him as far as it is in our power to understand the facts.

The businessmen and the patent lawyers are at fault in being violently hostile and non-co-operative toward the socialists. If you do not like a man, it is not fair to assume that he cannot have any honest opinions. If those in power have false ideas arising from ignorance of facts, it is the duty of those having knowledge of the facts to cure this ignorance regardless of how little respect they have for the ignoramus.

Mr. Crawford is quite right that the patent system has suffered from being linked up with antitrust matters. There is no real connection. The antitrust laws

deal with actions which are in restraint of trade by conspiracy or concerted action. The patent laws relate to rights primarily of individuals, since only an individual can apply for a patent, and no patent can ever be the result of a conspiracy. It is charged that patents are used illegally to further the ends of such conspiracies, which is true, but the remedy is to punish the conspiracy, not to amend the patent laws. Automobiles are used by criminals, but seizing all automobiles, while it may be an effective cure for this situation, is not a good solution.

We are suffering also because the patent lawyers, engineers, and inventors are too much inclined to follow rule 816, cited by Mr. Crawford, as to all improvements in patent procedure. To say that patent law and patent procedure cannot be improved is, obviously, to impute to a system an infallibility not found in anything of human contrivance. Of course, the system can be improved and greatly improved, and perhaps if we started to think about how it could be improved and spent less time abusing those who are seeking to improve it, we would all be better off.

Mr. Crawford speaks as an engineer accustomed to thinking accurately about realities when he says that to him invention merely means something new and useful. If we go back to the fundamental purpose of the patent laws, which is merely to encourage the production of new and useful things, it is hard to see wherein "invention" is at all essential. It is extremely hard to see why one man should be rewarded for producing something by a flash of genius and another refused a reward for something he has produced by long research and the sweat of his mind. If the result is new and useful, the public benefits equally regardless of how it is produced. It has long been my opinion that we could well abandon this archaic idea that invention is anything more than a specialized form of mechanical skill, and I think if the claims of a patent correctly and fairly define the degree of novelty and a reasonable degree of utility due to this novelty is present, the patent should be held valid. I have urged this view on my brethren at the bar, but we have so long dwelt under this fiction of invention that we believe it has some validity. Few engineers of my acquaintance accept it, and perhaps the reason this theory appeals to me is that I made a precarious living as an engineer for a considerable period before I broke down the fence into what I thought was a greener pasture.

What Mr. Crawford says about compulsory licensing is very true. It is extremely hard to conceive of any governmental bureau that could decide what would be a fair royalty. In fact, the hardest problem we patent lawyers have is to fix damages for infringement in which the actual damage to the patentee and the profits of the infringer are susceptible of some proof. If we cannot fix what is a fair compensation to a patentee for use of his invention after this use has occurred, I think it impossible to guess at what would

be a fair compensation before the use occurs. It is true that we arrive at such rates by bargaining when licenses are granted, but the whole theory of collective licensing is based on the theory that bargaining has been ineffective and that the patentee should be forced to grant a license on terms unacceptable to him. Obviously, the patentee is about as badly situated if his patent can be used by anyone on terms fixed by a governmental agency as he would be if it could be used without any compensation. The socialists adhere to the doctrine that there should never be an absolute right to any private property, and their attempts to abolish patents are quite consistent. One valuable by-product of this war, however, is undoubtedly the lesson being taught the American people as to how Government, by the compulsion of Government bureaus, works. A chance remark made by a high official of the Government that, if an inventor does not himself make full use of his invention, he should be forced to allow others to use it, is at the base of this movement for compulsory licensing and is only one phase of the general theory that all private property rights are subject to confiscation if some governmental official thinks it necessary, the price to be paid being fixed by the Government. Such a right of eminent domain, of course, has existed as to land for a long time, and under war regulations it exists as to many other things. Particularly it exists now as to patents, and there is now no need to go to compulsory licensing to further our war effort. The socialists, while they are in power, are trying, however, to set up their new social order so that we shall live under a system set up to win the war after the war is over.

Mr. Crawford deserves the thanks of every citizen of the United States for his very acute analysis of this situation, and particularly because he has given the engineers something to think about. The kind of world your children and my grandchildren will live in depends upon how clearly the American people can think, and those who are trained and paid to think had better work overtime at it.

I think, however, that the time has come for an impartial and thorough survey of the whole patent system, and I have some hopes that the Patent Planning Commission can do some good. I am afraid that it is too big a job for any part-time organization, however well qualified its membership. The President, in my opinion, made a very wise selection in naming the members of the Patent Planning Commission, but I do not think the job can be done without a vast amount of work and without incurring considerable expense, and certainly it cannot be done without help from the engineering societies and business organizations. It is even possible that the Patent Bar could help a little. The Patent Office can, of course, be of great help, but the Patent Office does not have much contact with patents after they are issued, and only a rather narrow contact with industry at any time. There are few evils within the Patent Office, except lack of money and

facilities, that the commissioner does not have power to cure. If Congress would give the Patents Planning Commission a substantial appropriation so that it could hire assistants to collect facts and do the necessary paper work, I think our chance of getting any results would be much better.

In any event, I would favor a working patent committee under the chairmanship of Mr. Crawford in the Institute or, better, a joint committee of all the engineering societies. Certainly the engineers should interest themselves actively in regard to any proposed reforms that vitally affect their interests.

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NEW BOOKS . . .

The following new books are among those recently received from the publishers. Books designated ESL are available at the Engineering Societies Library; these and thousands of other technical books may be borrowed from the library by mail by AIEE members. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books. All inquiries relating to the purchase of any book reviewed in these columns should be addressed to the publisher of the book in question.

Hypergeometric and Legendre Functions with Integral Applications to Equations of Potential Theory. By C. Snow. United States Bureau of Standards, Washington, D. C., 1942. 319 pages (photo-offset of long-hand), diagrams, 11 by 9 1/2 inches, paper, \$2. (ESL.)

This work has been compiled for workers in applied mathematics and is intermediate between tables of the numerical values of these functions and a treatise on their pure theory. The linear and quadratic transformations and analytic continuations of the ordinary hypergeometric function are derived and written out at length with special space devoted to the associated Legendre functions, and to a smaller extent Heun's generalization of the hypergeometric function. Many applications to potential theory are developed.

Television Standards and Practice. (Selected papers from the Proceedings of the National Television System Committee and its panels.) Edited by D. G. Fink. McGraw-Hill Book Company, New York, N. Y., London, England, 1943. 405 pages, illustrations, etc., 9 1/2 by 6 inches, cloth, \$5. (ESL.)

This volume has been compiled from the National Television System Committee *Proceedings*, on which are based the standards for television broadcasting in use in the United States. The papers chosen for the present book are those that directly underlie the official standards. They comprise a symposium on the engineering

problems of the television engineer and the radio industry.

Table of Arc Tan X. Prepared by the Federal Works Agency, Work Projects Administration for the City of New York, as a report of official project 165-2-97-22, mathematical tables project. A. N. Lowan, technical director; conducted under the sponsorship of and for sale by the National Bureau of Standards, Washington, D. C., 1942. 169 pages, tables, 11 by 8 inches, cloth, \$2. (ESL.)

This table of the inverse tangent is claimed to be the most comprehensive yet published. The angle is given in radians, and the function is calculated to 12 decimals, calculated over the range of x from 0 to 10,000.

Engineering Mechanics. By G. N. Cox. D. Van Nostrand Company, New York, N. Y., 1943. 301 pages, diagrams, etc., 9 1/2 by 6 inches, cloth, \$3. (ESL.)

Endeavors to co-ordinate the desires of engineering teachers as expressed in the surveys conducted by the Society for the Promotion of Engineering Education. The book is intended for undergraduate students majoring in engineering, and calls for a working knowledge of physics and the calculus.

PAMPHLETS . . .

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Patents at Work, a Statement of Policy. Officer of the Alien Property Custodian, Washington, D. C., 1943. 25 pages.

Welding and Brazing Alcoa Aluminum. Aluminum Company of America, Pittsburgh, Pa., 1942. 99 pages, no charge.

A General Outline of Restricted Relativity. By Vladimir Karapetoff. Scripta Mathematica, New York, N. Y., 1943. 18 pages, 35 cents.

A Course in Radio Fundamentals. By George Grammer. American Radio Relay League, Inc., West Hartford, Conn., 1942. 104 pages, 50 cents.

Electric Arc Welding Machine and Electrode Standards. Publication No. 42-81, National Electrical Manufacturers Association, New York, N. Y., 1943. 75 cents.

The American War Standard for Protective Lighting of Industrial Properties. American Standards Association, New York, N. Y., 1942. 50 cents.

After the War—Toward Security. National Resources Planning Board, Washington, D. C., 1942. 61 pages.